TEACHER TRAINING THAT MEETS THE NEEDS OF MATHEMATICALLY GIFTED LEARNERS

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ABSTRACT

In Africa, there is increasing evidence that progress being made in producing scientists, engineers and technologists is very slow. Yet, there is a total neglect of mathematically gifted students who have the potential to enter these careers. This is mainly due to teachers not receiving adequate training on education for gifted learners. This paper examines the necessity for and provision of suitable training for teachers who are required to teach gifted learners in mainstream classrooms. Using Gagné's differentiated model of gifts and talents (Gagné, 2015), the paper shows how gifts might never translate into talents if teachers are not trained to effectively nurture such talent. The model further implies that gifted students are found in mainstream classrooms, suggesting that all teachers encounter gifted students in a similar way to that in which they encounter learners with learning difficulties. The paper proposes that all pre-service teachers should receive training in education for gifted learners. The paper concludes by suggesting four broad components of a programme for training teachers to teach gifted students: changing beliefs and attitudes, the nature and identification of gifted students, the differentiated curriculum, and the assessment of gifted learners.

Keywords: *Gifts, talents, gifted education, skills development, teacher training*

INTRODUCTION

There is a global discourse that positions mathematical competence as the key that unlocks the gate to many opportunities for individual students and to the welfare of a nation in a 21st-century knowledge economy. Many of the most sought-after careers depend on the use of mathematics. For example, civil engineers use mathematics to determine how to best design new structures; economists use mathematics to describe and predict how the economy will react to certain changes; investors use mathematics to price certain types of shares or calculate how risky particular investments are; software developers use mathematics for many of the algorithms that make programs useful. Despite this global consensus, in Africa, there is increasing evidence that progress in producing such skilled people is not yet satisfactory (Department of Science and Technology, 2008). One might then ask: "What factors are contributing to this failure and what can be done to alleviate the challenges?"

This theoretical paper is premised on empirical evidence that has shown that mathematically gifted individuals have the potential to become the critical human capital needed for driving modern-day economies. The majority of these gifted students in developing countries spend most, if not all, of their academic career in mainstream classrooms, as a result of inclusive practices that led to the dismantling of special schools for the gifted. Although the presence of gifted students in almost every classroom indicates the need for teacher preparation programmes to include content on gifted students, empirical evidence shows that typical traditional pre-service teacher programmes do little to prepare teachers to meet the needs of gifted learners (Diezmann & Watters, 2002; Oswald & De Villiers, 2013). This suggests the need for a paradigm shift in the way traditional teacher training programmes are conceptualised and designed in developing countries. In light of the aforementioned, the purpose of this paper is to examine the necessity for and provision of suitable training for teachers who are required to teach gifted learners in mainstream classrooms. The following questions guide the paper:

- Why should mathematically gifted students and their teachers be of concern to us in the 21st-century economy?
- What competencies do teachers need to effectively teach gifted students?
- How should teacher training programmes be designed to prepare graduates who are ready to teach well in the 21st-century classroom?

MAKING A CASE FOR MATHEMATICALLY GIFTED STUDENTS

According to Smith (2004), it has been widely recognised that mathematics occupies a rather special position in our lives. It is a major intellectual discipline in its own right, and provides the underpinning language for the rest of science and engineering, as well as other disciplines in the social and medical sciences. It provides the individual citizen with empowering skills that prove useful in private and social life, as well as key skills that are required at virtually all levels of employment. There is not a single area of life that is not affected by mathematics. For this reason, many scientists regard mathematics as the language of nature. If our citizens want to learn about nature (and want to learn to appreciate nature), it is necessary to understand the language (mathematics) of nature. Supporting this view is the widely accepted belief that all citizens should be able to cope with the everyday mathematical demands of life (numeracy) at school, in the home, at work and in the community. However, beyond basic numeracy, advanced economies need an increasing number of people with more than the minimum qualifications in mathematics to stay ahead in the field of international competitiveness and to effectively exploit advances in technology. Thus, the goals of contemporary mathematics education are twofold: to develop a numerate citizenry, because mathematics is found everywhere, and to develop a society with sufficient high-level mathematical capability that will give a country the competitive edge in the 21st- century knowledge economy.

In this regard, MacGillivray (2000) suggests three distinctive levels of mathematical capability: the quantitative capability of society, the mathematical capability in the broad spectrum of areas with quantitative links, and the capability in terms of high-level expertise of the discipline of mathematical sciences. It is in the latter two levels of mathematical capability that there have recently been increases in both importance and danger signs (Diezmann & Watters, 2002). In particular, there is a need to understand how to adequately cater for exceptional students, such as those who are gifted in mathematics, so as to achieve the third level of capability (high-level expertise). A major reason why society continues to be concerned about the education of mathematically gifted students is the belief that mathematically gifted individuals have the potential to become the critical human capital that is needed to drive modern-day economies. While this assumption has been made intuitively, Terman's genetic studies (Friedman & Martin, 2011) and the longitudinal Studies of Mathematically Precocious Youth (SMPY) (Lubinski, Benbow & Kell, 2014) are arguably among the most famous longitudinal studies done in psychology to date that have tracked mathematically gifted youth over decades. These studies aimed to confirm or refute this intuitive thought. Results from these studies have confirmed beyond any doubt that mathematically talented males and females will indeed become the critical human capital that is needed to drive modern-day conceptual economies.

Although the neglect of gifted students in South Africa over the past two decades has been blamed on post-apartheid inclusive practices that were skewed towards addressing the needs of the historically disadvantaged population groups, ample evidence shows that authorities are now coming to realise that a democracy such as South Africa, more than any other system, requires an abundant supply of such talent and leadership if it is to survive and prosper. For example, in 2010, South African President Jacob Zuma appointed the National Planning Commission (NPC) to take a broad, cross-cutting, independent and critical view of the challenges facing the country. In its first diagnostic overview, the NPC (2011) raised its concern that skills acquisition was out of line with the needs of a modernising economy, because there was so much focus on numeracy at the expense of critical skills development. The NPC referred to this gap as “credential inflation” without a concomitant rise in earnings or skills requirements. With respect to students, the NPC’s view was that a few well-motivated and talented individuals would be of more importance to the national economy than many who were not at the cutting edge and were content with substandard work. The NPC then recommended the provision of opportunities for excellence for the most talented students.

Following the diagnostic overview by the NPC, the Department of Basic Education set up a task team to investigate the implementation of maths, science and technology (MST) talent development programmes in schools. The evidence gathered by the task team, with specific reference to talent search and development, showed that, more often than not, provincial education departments seemed to focus on under-performing schools, while neglecting gifted learners and learners with MST potential (Department of Basic Education, 2013:48).

Their recommendations were as follows:

- MST talent development programmes should be incorporated into the revised national MST strategy.
- At least one dedicated Mathematics and Science Academy or a special Mathematics, Science and Technology School should be established in each province. The school should preferably have a boarding facility to accommodate learners and teachers from across the province, but it should be managed nationally.

The Department of Science and Technology (2008) made similar observations. It set up a committee to undertake a study titled "Review of Mathematical Sciences Research at South African Higher Education Institutions". Its interviews with students who had chosen mathematical studies left the team wondering how many talented mathematics students had been lost, and how many young people had never had the opportunity to develop a love for mathematical sciences. They further argued that the ultimate health of mathematical sciences depended on strengthening the foundation of mathematics in schools, identifying and nurturing the best students at secondary level, and encouraging such students to enter programmes in the mathematical sciences. Its recommendation was that a vigorous mathematics talent search was needed at school level, particularly in the rural areas, where there is a huge reservoir of untapped talent.

At provincial level, there has been a similar focus on gifted students. For example, a document entitled "Gauteng Mathematics, Science and Technology (MST) Education Improvement Strategy 2009–2014" (Gauteng Department of Education, 2010) set out the strategy and plans to improve MST education in the province. An important observation made in this document regarding gifted students was that the majority of school learners in Gauteng are in schools located in economically disadvantaged communities, therefore, statistically, the largest provincial pool of potential future scientists, engineers and technologists is in these communities. Yet, there are more challenges in respect of MST education in these schools than in more affluent schools. The provincial department lamented that it was "a tragic inevitability that we waste much human potential with each generation of school leavers that suffers as a result of poor MST education" (Gauteng Department of Education, 2010:47–48). Its recommendation was that there is a need for early talent identification, and nurturing and developing this human potential. All these recommendations suggest that if we are to transform student potential into the skills that we need in the 21st century, we need to put well-structured talent development programmes in place for our gifted students.

THEORETICAL MODEL THAT PUTS TEACHERS AT THE CENTRE OF TALENT DEVELOPMENT PROGRAMMES

This paper borrowed from Gagné's differentiated model of gifts and talents (DMGT) (Gagné, 2015) as a theory that represents the process of transforming natural abilities (gifts) into skills (talents). This model is strongly anchored in the separation of these basic concepts (gifts and talents). In 1985, Gagné first conceptualised his theory of talent development (the DMGT), which is internationally renowned and has been modified over the years.

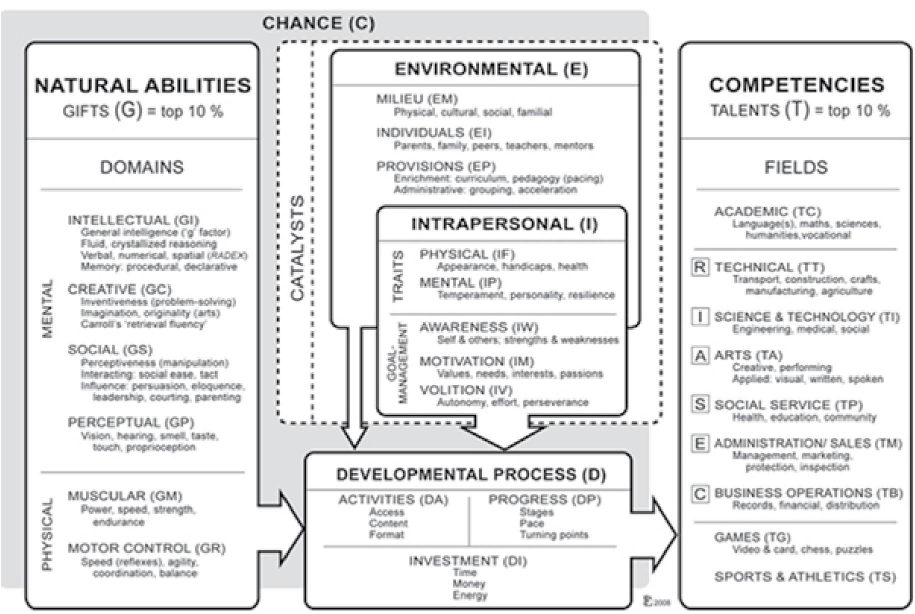


Figure 1: Gagné's differentiated model of gifts and talents (Gagné, 2009) (reproduced with the permission of Gagné)

The DMGT comprises six components, each being assigned an identifying acronym. As indicated in Figure 1, the components demonstrate the progression from natural abilities or gifts (G) to competencies or talents (T). This progression is facilitated through the developmental process (D), which is either assisted or hindered by factors that Gagné describes as catalysts. He groups these catalysts into environmental (E) or intrapersonal (I) catalysts and also includes the chance component (C) as a factor that can impact on all the contributing components of the model.

This model emerged as Gagné (2015:15) defined giftedness and talents as follows:

> *"Giftedness designates the possession and use of untrained and spontaneously expressed outstanding natural abilities or aptitudes (called gifts), in at least one ability domain, to a degree that places an individual at least among the top 10% of their age peers."*

"Talent designates the outstanding mastery of systematically developed competencies (knowledge and skills) in at least one field of human activity, to a degree that places an individual at least among the top 10% of "learning peers" (those that have accumulated a similar amount of learning time from either current or past training)."

In this way, Gagné (2015) differentiated between giftedness as raw capacity, and talent as systematically developed ability. One very important outcome of viewing the concept of giftedness and talent through the lens presented by Gagné (2015) is the implication that a child can, by virtue of having naturally high abilities, be recognised as being gifted from a very early age. As the child matures, these abilities will develop into talents; but the course such development takes is dependent upon the impact of what Gagné (2015) describes in his model as "catalysts", that is to say, the influences of environmental and intrapersonal factors.

He also includes the chance factor as being influential in the eventual successful or otherwise outcome of the developmental process. The outcome of a successful developmental process is the maturing of these basic abilities into exceptional competencies or talents. Thus, a person is described as being gifted to highlight that they have exceptional abilities and, when they have favourably developed these abilities, they may be described as being talented. Therefore, to be described as being talented necessarily implies giftedness as a prerequisite. A further implication is therefore that, while such a child will always remain gifted, only when a high level of performance has been attained can they be described as being talented. This is important, as it alludes to the common phenomenon in our schools, and in life, of under-achievement by the gifted, and points us in the direction of beginning to understand – and therefore remedy – this (Gagne, 2009). It supports the important understanding that if, through unfavourable catalytic circumstances, a child's abilities fail to manifest into talents, the basic constituents of their giftedness do not disappear, and therefore neither do their special educational needs. In fact, they are likely to be even more in need of intervention and support.

Besides this distinction between giftedness and talent, another important question that has caused controversy in the field of the education of gifted learners has been the following: "Who deserves to be labelled as a gifted student?". Gagné (2010) was particularly concerned about treating gifted students as belonging to a homogenous group, arguing that there are different levels of giftedness. As an intrinsic component of his DMGT, Gagné then developed a clear and defensible metric-based (MB) system, which allows for much easier comparisons of subgroups within the gifted or talented populations. The DMGT of Gagné (2010) proposes a five-level system of cut-offs for giftedness. These are the following: “mildly gifted” – 10% (top 1:10); “moderately gifted” – 1% (top 1:100); “highly gifted” – 0.1% (top 1:1 000); “exceptionally gifted” – 0.01% (top 1:10 000); and “extremely gifted” – 0.001% (top 1:100 000) (see Table 1).

Table 1: Levels of giftedness

Level	Labels for giftedness	Proportions
5	Extremely (profoundly)	1:100 000
4	Exceptionally	1:10 000
3	Highly	1:1 000
2	Moderately	1:100
1	Mildly	1:10

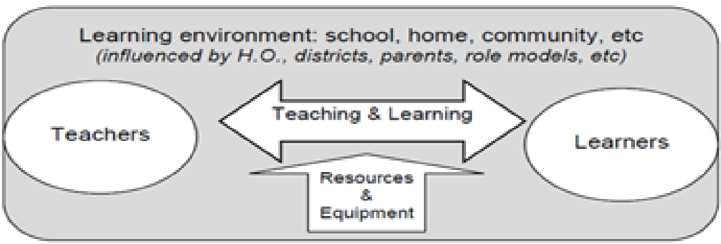
(Source: Gagné, 2000)

Using this MB system, Gagné (2010) argued that the mildly gifted (1:10) – or the top three achievers in a regular class of 30 – already distance themselves significantly in terms of ease and speed of learning. He refers to such mildly gifted students as the “garden variety” – a common English expression in the United States that means the “most common group”. Similarly, Renzulli (2012) uses the terms “high achieving” or “schoolhouse giftedness” to refer to students who are good lesson learners in the traditional school environment. So, in this paper, the term “gifted” is used in accordance with the recommendations of Gagné (2015) and Renzulli (2012) to refer to 1:10 students who attend everyday regular class and who demonstrate relatively high mathematical ability.

The focus on these “mildly gifted students” follows the recommendation of Gagné (2015) that the vast majority (90%) of gifted individuals belong to this lowest level, while highly gifted or talented individuals (1:100 000) are a rarity. The level of this rarity is such that even full-time teachers of the gifted may, in the course of their 35-year professional careers, encounter just a few, if any, of these extremely gifted students. His concern was that, when we present extreme examples of behaviour to parents or teachers, we risk conveying a distorted image of gifted individuals, because stakeholders would be tempted to conclude that such a rare population does not justify large investments of time and money to meet their educational needs.

Gagné (2015) therefore recommends that gifted and talented programme coordinators should first think about services for their "garden-variety" or "mildly gifted" students. In education systems that are guided by the inclusive philosophy, the "garden variety" of gifted students spends the majority of their time in regular classrooms – hence it can be argued that every teacher should be regarded as a teacher of the gifted.

What also makes the model of Gagné (2015) particularly relevant for this paper on support for gifted learners is the place given to teaching and learning within the developmental process. In his model, the developmental process of learning, training and practice combines with environmental and intrapersonal catalysts to transform natural aptitudes into skills that can be publicly demonstrated. Gagné (2015) sees the interplay of the catalysts as a chain that breaks if any link is missing, weak, ineffective or does not meet the learner's needs over a period of time. Gagné (2015) further argued that, within environmental catalysts, teachers (individuals) deserved to be labelled the "weakest link", because all the other catalysts (resources) are manipulated by the teacher. Similarly, Clark (2002) argued that classroom teachers have the most significant influence on the learning, development and achievement of gifted learners. In South Africa, the Gauteng Department of Education (2010) also conceptualised a model that places the teacher at the centre of the teaching and learning process. This is known as the intervention model for the MST Improvement Strategy, and is illustrated in Figure 2.



(Source: Gauteng Department of Education, 2010:29)

Figure 2: Intervention model for the MST Improvement Strategy

This model sees teachers and learners as the primary actors in MST education, supported by, but not entirely dependent on, resources and influenced by a range of learning environment factors and role players. The model works from the

assumption that the nature of the teaching and learning behaviour of teachers and learners determines the success of any education system more than any other factor. Research and reality show that the achievements of students, regardless of the type of school at which they are taught, depend on good teachers who are responsible for the quality of their work. Other factors, such as resources and the learning environment, are important, but not definitive. But once we point a finger at teachers as the weakest link, we are indirectly pointing at teacher preparation programmes. In South Africa, Van der Westhuizen and Maree (2006) argue that teacher colleges and universities should be the major advocates for improving gifted education, because they exert a direct influence on the education of gifted children by training (or not training) future teachers. Similarly, Oswald and De Villiers (2013) argue that the quality of gifted education is dependent on the quality of training the teachers receive – yet teachers who took part in their study said that they had not been trained to deal with gifted students.

THE ISSUE OF WHO SHOULD BE TARGETED BY TEACHER TRAINING PROGRAMMES

In countries where gifted education has been separated from mainstream provisions, training has always been targeted at specialist teachers, who then teach in special schools for the gifted. However, separate schooling for the gifted is not favoured in many developing countries, given its association with colonial practices of the past. A major feature of post-democracy reforms in education in many developing countries was a paradigm shift from an exclusive (colonial) system of education for the gifted to an inclusive (democratic) system. These efforts have culminated in the closure of centres for the gifted in some countries, and the emergence of a single education system for all. The majority of authors who oppose separate education for the gifted agree, in principle, that adequate provision can be made for such students in the regular classroom (Ainscow, 2007). In many developing countries, where the objective of education is primary education for all, stakeholders are usually hostile to and resentful of extra resource allocation to programmes for the gifted, which are seen to favour a few students. In such countries, Van der Westhuizen and Maree (2006) warn that it is difficult to justify separate programmes for gifted children; hence meeting the educational needs of the gifted has to be addressed within the inclusive framework. Gagné (2009) suggests that, in education systems that follow this inclusive philosophy, every teacher should be regarded as a teacher of the gifted. For this reason, Davison (1996) argues for all teachers to be taught how to meet the needs of gifted students, since these students spend most of their class time in a regular classroom. This implies that, in planning for "the future that we want", training in gifted education should be mandatory for all pre-service teachers. This view is also consistent with the wider approach to inclusive education, which locates special education theory within a functionalist paradigm. This functionalist paradigm is concerned with learners who experience learning breakdowns, as well as those who evidence gifted behaviour and for whom either enrichment or acceleration could be used to ensure that the gifted learner is not neglected.

SOME THOUGHTS ON THE DESIGN OF TRAINING PROGRAMMES FOR TEACHERS OF GIFTED LEARNERS

Admittedly, there are various views as to what should go into a programme for training the teachers of gifted students. However, studies concerned with the essential competencies of teachers of the gifted are relatively consistent in their assessment of which competencies should be found in educators working with gifted students (Cross & Dobbs, 1987; Hansen & Feldhusen, 1994). Some of the critical concepts that need to be considered include a change in beliefs and attitudes, the nature and identification of gifted students, a differentiated curriculum and assessment. Each of these competencies will now be discussed.

Beliefs and attitudes

Lewis and Milton (2005) and Plunkett (2000) have highlighted the importance of beliefs and a positive attitude as a starting point in addressing the needs of the gifted. While the relationship between attitude and behaviour is complex and not always consistent, it is generally agreed that attitude is one variable that influences a person's behaviour or behavioural intent, perceptions and judgment (Bohner & Wänke, 2002). Research shows that, 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 pre-service teachers about gifted students is not challenged, they will retain this attitude in professional practice.

Lewis and Milton (2005) agree with Plunkett (2000) that teachers' and pre-service teachers' beliefs and attitudes have a significant impact on their classroom practice. In a study of the characteristics of effective teachers of gifted students, significant factors identified included passion for their subject matter, positive relationships and a capacity to relate new learning to students' interests (Watters, 2010).

Similar studies have shown that teachers who participate in gifted education programmes have a more positive attitude than those who do not avail themselves of such opportunities (Lassig, 2009; Plunkett, 2000).

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. According to Gross (2004), teachers should be trained in research and exposed to research findings that contradict many of the misconceptions held regarding gifted education. This may assist in dispelling the myths and misconceptions about giftedness and gifted children. Enhanced knowledge, understanding and skills, and a related increase in confidence, may reduce unfavourable attitudes.

Change of attitude is not only important for pre-service teacher training, but also in the in-service training stage. For example, Davis and Rimm (2004) recognise the significance of attitudes towards the gifted when developing programmes. They recommended that the first question to be asked when devising a programme for gifted learners should be: "What is our attitude towards gifted children?" (Davis & Rimm, 2004:55). This is important in developing a successful programme, because schools must identify what they 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. Schools need to know why they are providing a particular programme, what they are aiming to accomplish, and whether they are willing to be responsible and accountable for the plan of action (Davis & Rimm, 2004). A negative attitude and prejudice can cause discriminatory behaviour, particularly when it exists within a group, for example, 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 effective in identifying and catering for gifted students.

The nature and identification of giftedness

Besides teacher attitude, another major concern that pre-service teachers have is a lack of understanding of the nature of giftedness, stereotypical views of the rarity of gifted students and hence a lack of awareness of the prevalence of children who need enhanced or enriched educational experiences beyond what is normally provided in classrooms (Watters, 2010). One of the commonly voiced concerns regarding gifted education is that traditional methods of identifying gifted children are culturally biased and, more importantly, that traditional conceptions of giftedness are narrow and skewed towards certain cultures (Gottfredson, 2004). Pre-service teachers should therefore be exposed to more diverse methods of identifying gifted students. Equity requires more diverse and more sensitive means of finding those unrecognised, potentially gifted students who have yet to reveal their true capabilities.

Reflecting a broader trend in gifted education, both Ford (2011) and Richert (2003) advocate a multidimensional view of giftedness and corresponding multimodal ways of identifying it. Those who support a multidimensional approach present their broader conceptions as being more democratic, as they are more inclusive than the traditional intellectual approach. In short, Gottfredson (2004) argues that if our tools for identifying giftedness do not produce racial balance, we should modify them until they do.

Differentiated curriculum

Another major concern in gifted education is that, in practice, planning for differentiation poses substantial challenges to teachers. In order to cater for the diverse needs of gifted students, the most common approach that teachers can implement is to create opportunities for gifted students to realise their potential through a differentiated curriculum. According to Maker (1975), differentiation requires the modification of four primary areas of curriculum development: content (what we teach), process (how we teach), product (what we expect the students to do or show) and the learning environment (where we teach/our class culture). Teachers can differentiate the curriculum by removing mastered material from the existing curriculum, providing new content, and extending the curriculum with enrichment activities (Ashman & Elkins, 2009). Differentiation requires recognising students' varied background knowledge, language and learning interests. According to Harris and Hemming (2008), varied and practical teaching strategies facilitate diverse ways to assist gifted students to achieve learning outcomes. The skills necessary to plan and implement a differentiated curriculum can also be developed in pre-service programmes. Pre-service teachers themselves need to develop skills in higher-order thinking and creative thinking to develop content that is more abstract and engaging for students who seek complexity and challenge.

Assessment

Effective pedagogy requires assessment, which provides the critical links between what is valued as learning, ways of learning, ways of identifying needs and improvement (Pendergast & Bahr, 2010). Following this view, Ashman and Elkins (2009) emphasise the need for pre-service teachers, teachers and other professionals to identify what gifted students know (assessment) and how they learn in relation to effective teaching. Monitoring student engagement and performance through assessment strategies supports gifted students to scaffold academic skills and learning processes. Yet pre-service teachers are often unprepared to assess students' understanding (Callahan, Cooper & Glascock, 2003). This may also be overcome with teacher education training that promotes effective communication and collaboration in the classroom, including the provision of a variety of assessment strategies to improve teaching and learning.

CONCLUSION

This paper argued that mathematically gifted students are the hope for the future in the 21st-century knowledge economy. Currently, they are found in mainstream classrooms that follow inclusive education practices. In these classrooms, they are not receiving adequate support, as teachers are not trained in how to cater for the needs of gifted students. This is detrimental to our efforts to produce skilled people. The paper then argued that all teachers undergoing pre-service training should receive training in educating gifted learners. This training should involve changing teachers' beliefs and attitudes towards gifted education, the nature and identification of gifted students, the differentiated curriculum and assessment.

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