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Review Article

Gifted Education in Science and Chemistry: Perspectives and Insights into Teaching, Pedagogies, Assessments, and Psychosocial Skills Development

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Abstract

This article provides gifted education perspectives and creative insights with a particular focus on chemistry and science, and discusses associated teaching, learning, pedagogies, curriculum developments and assessments in the context of gifted education. The article emphasizes the cluster grouping approach, hidden curriculum, mentoring and proper counselling provisions in school that may significantly impact on gifted students' developments. The article discusses gifted students' psychosocial skills development to achieve their eminence. The implicated issues surround the development of psychosocial skills are discussed. The article sheds light on the cultural aspects of gifted education as the gifted students representing diverse cultural backgrounds encounter cognitive conflicts which affect their science learning and psychosocial skills development.

Keywords

gifted education, chemistry, science, teaching, pedagogy, assessment, curriculum, culture and psychosocial skills

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Introduction

There are a myriad range of definitions for gifted education found in literature. But no rigid definition of giftedness could be found yet which has wider acceptance. Recently Subotnik, Olszewski-Kubilius and Worrell (2011) outlined gifted education based on their research in psychological science, which is found to be the most comprehensive definition of gifted education to-date. The authors proposed a new framework, which may guide future research and practices; and described that, 1) in gifted education abilities are important. The amount and source of ability, the balance of general and specific abilities, and the exact nature of specific abilities vary by talent domain, which are not completely understood. 2) Giftedness is domain specific, and domains of talent (e.g., science and chemistry) have specific developmental trajectories across the life span. 3) Effort and opportunity are factors at every stage of talent-development process. 4) The psychosocial variables are important contributors to outstanding performance at every stage of talent development. Gifted students' psychosocial skills play the greatest role during their transition from expertise to eminence. Finally, 5) eminence should be the goal of gifted education (Subotnik, Olszewski-Kubilius & Worrell, 2011). Examples of eminence are creative break through contributions, discoveries, innovations, and extraordinary performances.

Gifted students are asynchronous, and their developments are uneven. They are highly emotional, and they have a higher awareness of outside world and environment. As a result, they may not find proper emotional resources to match their cognitive awareness (Hoekman, 1994; Silverman, 2009). In a mixed ability class, many teachers find difficulties to meet the pedagogical needs of highly gifted students. Gifted students expect their companionship with intellectual and emotional maturity. If they do not find such companionship, they may either conceal their intellectual and emotional maturity in a way that can be accepted to classmates, or they may isolate themselves, or try to adjust with age peers (Gross, 2004; Silverman, 1993).

Gifted education is strongly linked to the developmental needs of individual (Schulz, 2005). Effective learning can only occur when individuals can construct their own understandings (McInerney & McInerney, 2010). Thus the central focal point of learning is on the cognitive content of the minds of individual learner where social and other contextual factors affect the learning process. Current teaching and learning practices require more research to find out effective application that match the pedagogical requirements of gifted students where individual requirements, individual differences, abilities, cognitive, social, cultural, emotional, and other contextual factors are taken into consideration.

Students can be gifted in a range of knowledge domains. However, the giftedness in one domain does not guarantee their gifted thinking into other

domains. Some gifted students may display underachievement and learning difficulties (Munro, 2011). Gifted students are often intrinsically interested in science, however under the prevailing curriculum, dull routine, recall-based assessment, and lack of meaningful experiences may turn the gifted students away from sciences (Watters & Diezmann, 2003). Some young children have subconscious fears of chemistry which are sometimes transferred to them by their teachers, and many children have never had a meaningful or pleasant exposure to science (Greco & Greco, 1987). If the gifted students are challenged in appropriate way, it is most likely that they will display their latent abilities (Plunkett & Kronborg, 2007) and well performances. Thus a proper nurturing and non-threatening environment is required when science and chemistry are taught to the elementary school students, and the school provides challenging and meaningful learning experiences. Gifted students in science and chemistry are expected to display their expertise by the time they reach at the secondary level of school.

The article provides creative insights, critical analyses and reflections on gifted education perspectives in science and chemistry based on the consideration of current declining trend of students' motivation and engagements in sciences, enabling sciences in particular; lack of social and other implications with science, and to perceive science knowledge as useful, interesting and relevant. The author focuses on the pertinent issues related to science and chemistry and, discusses the associated teaching, learning, pedagogies, curriculum developments, and assessments in the context of gifted education. The article particularly emphasizes the cluster grouping approach, hidden curriculum, mentoring and proper counselling provisions in school that can significantly impact on gifted students' development. The article discusses gifted students' psychosocial skills development required to achieve their eminence. The implicated issues surround the development of psychosocial skills are discussed. The cultural aspects related to gifted education that affect gifted students' science learning and psychosocial skills development are illustrated. The information and discussions presented in this article may be helpful to teachers, educators, researchers, scholars, curriculum developers, schools and STEM education, and may effectively contribute to the improvement for a well-developed gifted education policy and curriculum.

Psychosocial Skills

Sternberg (1998) described that to develop an expertise five key elements are required to satisfy such as, metacognitive skills, learning skills, thinking skills, knowledge and motivation. These elements are fully interactive and can influence each other. For example, motivation drives the metacognitive skills, which in turn activate learning and thinking skills, and then provide feedback to the metacognitive skills. Such interactive and influencing aspects may lead a person to

increase the level of knowledge and expertise. Since all individuals are different, and will not equally and effectively engage, thus all persons will not necessarily reach the same ultimate level of expertise. Thus if abilities are forms of developing expertise as Sternberg (Sternberg, 1998) argued, then afterwards, the psychosocial skills and related aspects are most important as these aspects will lead a person to achieve eminence (Subotnik, Olszewski-Kubilius & Worrell, 2011), which is the ultimate goal of giftedness.

Psychosocial skills are important for success in all domains (Subotnik et al., 2011) including the STEM subjects. Lang, Wong and Fraser (2005) emphasized the importance of psychosocial aspects of the chemistry laboratory learning environment for the gifted students in a secondary school. The dynamic teacher-student interactions that take place in the classroom, and the interpersonal behaviour of teachers profoundly impact on students' attitudes towards chemistry. In teaching chemistry if a more open-ended learning environment is created it could be helpful in establishing a unique and enjoyable learning atmosphere for the gifted students. It is evident from research that, an open-endedness and material environment are significant predictors of gifted students' attitudes to chemistry. In this context, it was suggested to redesign the chemistry curriculum by customising the instruction that meet the learning needs of learners, and incorporate more lively and practical approaches. And, infuse scientific inquiry, creative and critical thinking skills into both theoretical and laboratory work (Lang, Wong & Fraser, 2005). This way it can help establish an enjoyable learning environment for the gifted and other students.

Teacher's personality plays a dominant role in the development of students' attitudes, values and ethics. Hence teachers may always be mindful of their professional developments, and grasp the required knowledge and skills and, be proactive participant in the areas of socio-political (United Nations Educational Scientific and Cultural Organization, 1991) and socio-scientific activities related to science and chemistry. Teaching may particularly focus on the articulation of the limited domain of scientific values, and how they can be integrated or linked to other values (Allchin, 1999) that exist in the society. Many teachers rarely suspect that classroom features, pedagogical style, or their own attitudes may influence powerfully on student's ability to succeed, and connect with the school environment (Phelan, Davidson & Cao, 1991). It is thus important that schools and teachers require more than understanding about other cultures; and, create the necessary environment where the students can acquire skills and strategies that lead them to comfortably work with different people in divergent social and cultural settings. A recent study was carried out in the context of Singapore that investigated teacher-student interactions, and gifted students' attitudes towards chemistry within the laboratory classrooms. The research revealed that the gifted

students had more positive perceptions than the non-gifted students. Positive teacher student interactions improved the perceptions and attitudes of gifted students in their chemistry learning, and, the enjoyment of chemistry lessons was significantly improved among the gifted students (Lang, Wong & Fraser, 2005).

The emotional nature and uneven types of development among the gifted individuals necessitates the provision of proper counselling. In one developmental study on the gifted students (Hoekman, 1994) revealed that, the inherent asynchrony characteristic of gifted students, which are the combination of cognitive complexity and emotional intensity, required proper attention from parents, teachers and counsellors on a regular basis along the way of students' developments. In this regard, Munro (Munro, 2011) suggested that, a regular educational counselling is important due to non-differentiated education provisions, which may prevent the students being alienated from schooling, and help overcome a range of emotional problems such as, unwanted stress, depression, extreme anxiety, and peer bullying. In this context, the author of this article believes that the school should provide a supportive and facilitative environment to gifted children so they can feel good about being gifted. And thus suggests a regular friendly and supportive 'cognitive therapy' based counselling arrangement in the school which could be more appropriate.

Mentoring provides an enormous impact on gifted students' psychosocial skills development. Mentor can serve as a role model who generally helps students' acquiring prerequisite skills to accomplish the goal than a class teacher, and provides access to advanced and specialised knowledge. With the help of mentors, the gifted students can pursue individual investigations or creative productions to a very high level of standard, challenge and display sophistication. Several studies by McCluskey and co-workers (2000 and 2003) revealed that, mentoring can be utilized to turn around the lives of disaffected, anti-social young or many dropped out school students who have a high potential to explore (McCluskey, O'Hagan, Baker & Richard, 2000; McCluskey & Mays, 2003). The gifted underachievers can also gain great benefits from mentoring. However, to find a real mentor or making the mentoring arrangements is a difficult task. This is where school management can play an active role in such arrangements.

Before embarking on a real-life career, the gifted students need to be well-prepared to handle various psychosocial problems and situations as they inevitably will encounter many problems. The psychosocial skills are important to gain success in all stages of human life span. The importance of psychosocial skills in real-life and adult scientific applications can be realized if it is viewed through the lens of sociology and anthropology. In this context, Latour and Woolgar (1979) portrayed the notion of science and scientific work as a sociological phenomenon. The authors constructed their observations after 2 years of close daily contact with

the laboratory scientists. Their observations were**:** how scientific work is conducted, the complex relationships between the routine laboratory practices, publication of papers, scientific prestige, research finances, and other elements of laboratory activities. The authors analysed them from anthropology and sociological point of views. It was found that the nature of relationships between the scientists and the investigators affected the production of reports about science; and the scientific logic and procedure was found severely threatened. As a result, scientists found their work were disrupted by the intrusion of external factors, where social factors were the most predominant. From anthropological point of view, although a scientific activity is considered to be highly creative in nature, but it is just one social phenomenon, in which scientific knowledge is constructed. The social construction of scientific knowledge helps scientists make sense of their observations (Latour & Woolgar, 1979) to produce effective outcomes, and consequently gain success.

Cultural Aspects Affecting the Psychosocial Skills Development

Success in science depends on**:** the degree of cultural difference that students perceive between their life-world and their science classroom; how effectively students move between their life-world culture and the culture of science or school science; and, the assistance students receive in making those transition easier (Jegede & Aikenhead, 1999; Costa, 1995; Phelan, Davidson & Cao, 1991).

In everyday life, students constantly interact with their own family, peers or friends, and school. The interaction between the students' life-world culture and the culture of school science may be conflicting, and may lead to a painful cognitive conflict which students want to overcome (Costa, 1995; Phelan, Davidson & Cao, 1991). The eradication of psychological pain can only ensure students' smooth cultural transition. If the conflict between what students bring into science classroom and their expectation to take away from classroom turns out to be serious, it can lead to a serious cultural conflict. Such conflict may occur in the arena of students own culture or in the realm of their beliefs or attitudes. Students require assistance when they attempt to negotiate these cultural borders which would influence their success at science. Thus teachers need to play a vital role in bridging the cultural gaps or differences between the students' life-world culture and the culture of science or school science, and connect them with the scientific content, and make students' science learning and cultural transitions easier.

Currently it is not clearly understood as to how the gifted students develop their own world-views, and the interrelationships between gifted students' family, peers, and school world; and how these aspects affect gifted students' engagement with schools and their learning; and, how gifted students' perception of boundaries

between life-world and their employed adaptation strategies move from one context to another. Thus it is yet to be uncovered as to how smoothly the gifted students penetrate their perceived boundaries during the course of travelling from one domain to another (i.e., family, peers and school world) or how they encounter and manage any conflict due to cultural-clashes. Especially the gifted students from culturally diverse background acutely face this problem.

In current situation, school science generally projects only one world view i.e., Western view, and, the Western view neither recognizes the variations among people nor the different world view which learners bring into science classrooms. The interaction between the Western mechanistic world view and the students' indigenous knowledge complicates their cognitive process which makes an obstacle to their science learning process. The Western students generally do not find difficulties to cross their cultural borders because of their Western background they do not have to learn the Western thought which requires undergoing a mental and cultural ecdysis (Jegede, 1995). Thus the non-Western learners face an extra obstacle in their understanding and learning science concept as they have to resolve the cognitive conflict that has created with the indigenous or non-Western knowledge base brought into the classroom. Many students within a multicultural environment, experience serious problems of their cognitive conflicts between those two worlds which affect their learning of sciences. Thus the gifted students who faces an extra cognitive conflict and, as they have to give extra efforts to resolve the conflict, and learn science properly, it certainly will have influence on their psychosocial norms and psychosocial skills development. Future research may focus on these cultural clashes and issues of conflicts that the gifted students, especially the students from diverse cultural backgrounds, encounter in their daily lives. Future research may attempt to ascertain the impediment factors for cognitive, affective and social developments of those particular gifted students.

Teaching, Pedagogies and Assessments

It is important that teachers understand the nature of the gifted learners, and are familiar with the particular strategies required to address their needs. The pedagogical needs of gifted children are not widely understood and, particularly in the regional areas, these are not frequently addressed in the professional learning. Many teachers do not feel confident in providing worthwhile enrichment for these students (Wood, 2009). It was argued that if the teachers have the 'conceptual tools' for gifted knowing and thinking in the context of teaching and learning, they are more able to interact with the gifted and talented students (Plunkett & Kronborg, 2007).

Teachers' professional development program should always provide special training, and adequate resources with pedagogical tools based on research, and

address these issues related to gifted education. Teachers are required to understand the perspectives on psychosocial and psychodynamics of the gifted students; and, build trusting relationship with their students through cooperation and communication process. Teachers should show their willingness to learn from and with students, know the orientation of students' family, parents and societies, students' hopes, fears, dreams, desires and interests; and how they think and perceive their own worlds. Teachers need support in all aspects, particularly the moral support. And such supports may help reduce their anxiety while they adapt with unfamiliar matters, issues, and pedagogical approaches. These supports may also help enrich teachers' experiences about instructional ideas and professional needs for the gifted students, and increase teachers' sense of ownership. As a result teachers can make significant impacts on the development and implementation of the teaching materials in gifted education.

The social constructivist or critical pedagogy based curriculum is an effective approach, particularly for gifted education and gifted teaching. Education is socially constructed and political in nature which always involves a constant unveiling of reality; and it is a process which undergoes constant transformation; it encourages students to be critical investigators and engage in dialogue with their teacher; and it does not dichotomize the activity of teacher and student, and is always cognitive. Knowledge can only emerge through invention, re-invention, restless, continuing efforts and hopeful inquiry to pursue in the world, with the world, and with each other (Freire, 1972). In this regard it must be acknowledged that along the line of the establishment of social constructivism, many past educators had contributed with their ideas, theories and work. Among them Jean Piaget and Lev Vygotsky were most instrumental. Piaget was the first who stated that learning is a developmental cognitive process. Students construct knowledge based on their experiences, and students create knowledge rather than receive them from the teachers. According to Vygotsky's idea, students' learning occurs in a cultural context and involves social interactions. Vygotsky's well-known concept of zone of proximal development (ZPD) suggests that students learn subjects best just beyond their range of existing experience with the assistance from their teacher or peer. Students then bridge the distance from what they know or can do independently as well as what they can know or do with assistance. Vygotsky viewed his ZPD concept as a way to explain in a better way about the relationship between children's learning and cognitive development (Hammond, Austin, Orcutt & Rosso, 2001). Currently the social constructivist approach has been adopted in many educational curricula around the globe, Australia, for example.

Students bring their prior conceptions to school. At the same time, teachers also bring their prior conceptions not only in terms of their subject or content knowledge but also in their view of teaching and learning. These aspects can

influence on their way of interacting in the classroom. This proposition (Driver, 1988) is found in alignment with the research findings reported by Lang et al. (Lang, Wong & Fraser, 2005). Thus it necessitates that teachers are fully aware of and, consider the formal and informal teaching and learning, and observe the impacts on their students. Students need help and require the provision of getting correct explanations to develop scientific skills, and understand the product or process of chemistry and science, and the nature and structure of chemistry or science; and how they have developed and grown intellectually. Students should develop adaptability to realize how chemistry and science can assist in understanding and controlling the environments. Students need to reflect on science, technology and decisions, various limitations of science and chemistry, the difference between science and technology, and how science and technology considerations differ from personal and political values (Roberts, 1982).

At the elementary level of chemistry teaching, teachers generally concentrate on the simple process skills such as, making observations, inferences, predictions and control variables. Gabel (1985) suggested, at the intermediate level, students should be introduced to acquire integrated process, reasoning, and complex skills, such as, graph construction, interpretation and testing hypotheses. At this age level, the gifted children are in the transition from concrete to formal operational reasoning state, and thus require opportunity to explore and exercise their skills. Since chemistry contains a hierarchy of concepts where one concept builds on another (Gabel, 1985), thus it is essential that the teachers provide proper theoretical and practical basis of teaching that enable their students understand the conceptual meaning and content knowledge in chemistry, which particularly applies to elementary school students.

The success or failure of an existing or a newly adopted curriculum with a particular set of curriculum emphases largely depends on teachers' values and beliefs. Teachers always remain the key and essential element in implementing and determining the success or failure of any curriculum, whether it is a general curriculum or a curriculum focuses on the gifted education practices. The curriculum development should put strong emphases on students' learning and acquiring scientific and chemistry knowledge. Curriculum developers may pay more attention as to how science can be useful to gifted students; how the schools' view of science implementation can shift towards a more genuine science of world view, and improve the assessments of student's performance in sciences (Watters and Diezmann, 2003). When the teachers are confronted with a new curriculum and, if they are not adequately consulted with, in that case, teachers have to make efforts to make sense of the curriculum. If the emphases contained within a new curriculum are significantly different from their previous experience, a greater effort is needed, which many teachers are not happy with nor are ready to take.

Thus prior to the introduction of any new curriculum teachers should be consulted and negotiated with various stakeholders and school.

It is important that teachers emphasize the hidden curriculum that deals with students' attitudes, values, and behaviour learnt in the school, and the culture of school and the family background. And all such aspects impact on students' development, and shaping their identities. Students generally pick-up hidden curriculum messages via a range of practices such as, comments from teachers, newsletters, what students are praised or suspended for, what is tolerated by the peer culture etc. All these factors influence students' experience of schooling, their own sense, and self-confidence or lack of it, and in their capacity and future pathways (McLeod, 2011).

Teachers may consider the cluster grouping approach, which can be a viable option to address gifted education for many schools where large number of gifted students may not be available to form a full-time gifted class. The cluster grouping arrangement (e.g., picking up the selective gifted students from various classes, and placing them in a mixed ability class) can be enormously helpful, and has strong and positive academic merits. It enables the teacher to plan tasks and appropriately challenge students in the gifted cluster. It also allows the gifted students to experience the benefits of mixing with academically and socially like-minded peers, and students are able to mix with age peers having varied abilities and interests. It was reported that gifted students can achieve approximately 60% more grade-equivalent knowledge and skills than equally gifted children who have not been clustered (Rogers, 2002). In the cluster groups, it is easier to move students in and out during the year which is otherwise difficult in the case of full-time ability grouped classes.

In teaching practices, the assessment task is extremely important to rigorously track down students' developments and changes, and their learning outcomes, especially when the gifted students are dealt with. In the diverse contexts, the interpretation of underlying concepts of curriculum and assessment affects the daily decision making about the practices of teaching & learning, and are constantly changing or shifting (Ewing, 2010).

Brady and Kennedy (2012) who extensively studied the assessment practices in school described that, the assessment is context dependent, and can shape its practices. The contexts should be student-centred and classroom-based where it takes place on a daily basis, and in the broader social and political context, in which schools are embedded (Brady & Kennedy, 2012). Prior to setting up any assessment strategy, teachers need to build up their observation skills to collect the respective data and evidence for their judgements. The continuous assessment is engaged with students' regular work, record of achievements, school-based assessment, and self-assessment by students and peers. It uses the results

formatively as feedback, and link the assessment with curriculum that cater varied requirements of students. It helps define the objectives of assessment to students, and encourages the learners to take greater responsibility for their own learning process (Williams, Johnson, Peters & Cormack, (1999). It also uses proper reporting system and regular communications with parents; and diagnostically guides the students to reinforce their learning.

Currently, standard or criterion-referenced assessments are most popular (Brady & Kennedy, 2012) however, teachers may intend to shift to a more authentic and flexible approach which is entirely depends on teacher's choice. The values, merits, and practices of an authentic assessment depends on the culture of classroom, school, pedagogical approach, expectations, standards of performances, and students' self-critical judgement capabilities (Williams, Johnson, Peters & Cormack, 1999). More importantly, it requires the willingness and aim-talks between teachers, students, schools, and parents. It is important that in gifted education practices both teachers and schools pay careful consideration of student assessments. During the course of teaching and, while gathering data, various difficulties and flaws can distort the received information about the learner's understanding, and can lead to raise questions about the validity, reliability and credibility of assessments (Kempa, 1986) being practiced. It is particularly more important for the gifted students since a great deal of sensitivities is involved in their teaching practices.

Conclusion

The article presented gifted education perspectives and creative insights with a particular focus on chemistry and science. It discussed associated teaching, learning, pedagogies, curriculum developments, and assessments in the context of gifted education.

The psychosocial skills are important in all stages of human life to gain success, particularly for the gifted students in chemistry, science and STEM subjects, and help the gifted students to achieve their eminence. Mentoring and proper counselling provisions in school can significantly impact on gifted students' psychosocial skills development. Teachers' understanding of various cultures, values, attitudes, appropriate teaching styles, and positive teacher-student interactions can profoundly impact in enhancing gifted students interest, motivation, and enjoyment of learning chemistry and science. The gifted students from diverse cultural backgrounds encounter cognitive conflicts which affect their learning of sciences, and psychosocial skills development.

Teachers understanding of the pedagogical needs and approaches, and having the right conceptual tools are paramount for their appropriate teaching instructions

to gifted students. At the intermediate level, the gifted students are required to grasp the integrated process, reasoning, and complex skills with proper theoretical and practical instructions. In order to become expertise in science and chemistry, emphasis should be given on the development of metacognitive skills, learning skills, thinking skills, knowledge, and motivation.

During curriculum development emphasis should be given on the way of students' learning and acquiring scientific and chemistry knowledge. Teachers' assessments should focus on student-centred and classroom-based teaching and learning practices. Effective communication with students through the right assessment and feedback mechanism is crucial in the gifted teaching.

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