SCIENCE EDUCATION AND STUDENTS WITH INTELLECTUAL DISABILITY: TEACHING APPROACHES AND IMPLICATIONS

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Abstract

This literature review aims at discussing current educational perspectives in the specific field of science teaching to students with mild to moderate intellectual disability. The present critical approach focuses on the availability and appropriateness of teaching methods and learning strategies that might effectively support science education of students with intellectual disability, given the cognitive characteristics, the learning difficulties and competencies of these students, the particular academic and learning skills associated with the acquisition of science concepts, and finally the perspective of promoting the access of students with intellectual disability in the general educational programs. Discussion of the evidences reveals a complex picture, which suggests further empirical verification of the research findings specifically in regard to the inquiry learning method and its implementation on science teaching to students with intellectual disability. Given the implementation of the appropriate instruction methods and learning strategies, science education and even more inclusive science education with an emphasis on hands-on activities and real life experiences could yield benefits, at least for students with mild to moderate intellectual disability, related to their everyday functioning in the context of functional academic skills acquisition.
Key words*: science education, teaching methods, intellectual disability.*

Introduction

People with intellectual disability are characterized by significant limitations in cognitive functioning and adaptive behavior (Schalock & Luckasson, 2004, p. 139). A major issue in the field of intellectual disabilities is the development of appropriate individualized support that should be differentiated in accordance, among others, to the specific difficulties and the potential that characterizes a person with intellectual disability. Undoubtedly, the reliable assessment of the individual characteristics of people with intellectual disability in cognitive and behavioral level is of great and critical importance, considering both competencies and limitations, in order to appropriately organize and adapt the support provided, as well as the content of the educational programs and interventions (Fidler, Philofsky, & Hepburn, 2007; Hodapp, DesJardin, & Ricci, 2003; Hodapp & Fidler, 1999).

A major part of scientific sources in the field of intellectual disabilities, focuses on the education of people with intellectual disability and moreover on the methods, practices, and the appropriate modifications or adaptations that would promote their access, participation and progress in general education

(Algozzine & Ysseldyke, 2006; Wehmeyer, 2002; Wehmeyer, Lance, & Bashinski, 2002). Among other academic subjects, science is an important content area of the general education curriculum. It is suggested that the substantive knowledge about the world is very interesting and important and is one of the reasons for teaching science in a school (Vavougios, Xanthakou, Chionidou, & Kaila, 2003). On the other hand, teaching science to students with intellectual disability in inclusive environments emerges many challenges, considering their learning characteristics.

The aim of this paper is to selectively review research studies focused on science teaching to children and adolescents with mild to moderate intellectual disability. Specifically, evidence on the effectiveness and appropriateness of several science teaching practices and methods based on constructivist principles and hands-on activities are presented and critically discussed in the context of science education of students with intellectual disability. According to the research evidence presented, several factors related to the effective implementation of science teaching strategies are also discussed. Certain basic cognitive characteristics of people with intellectual disability are generally discussed with an emphasis on their possible impact on organizing educational interventions and, specifically in the case of science education, on selecting the appropriate teachings methods and on applying appropriate adaptations.

Cognitive Characteristics of People with Intellectual Disability and Educational Perspective

Cognitive functioning of people with intellectual disability has been studied in the light of different theoretical and methodological approaches. The nature of several cognitive difficulties is still under investigation, as well as the impact of these difficulties on learning in people with intellectual disability. Current research in the field of intellectual disabilities is interested in understanding the endogenous or exogenous factors that affect cognitive development and functioning of people with intellectual disability and the role of cognitive and non cognitive factors that affect their performance in specific cognitive tasks (Hodapp & Zigler, 1999; Silverman, 2007).

The performance of children with intellectual disability, mostly in information processing tasks, reveals several limitations in cognitive strategies use, although individual variations were noticed regarding their strategic behaviors (Dermitzaki, Stavroussi, Bandi, & Nisiotou, 2008). Research evidence, regarding performance on memory tasks, suggested that people with intellectual disability face difficulties in memory strategies use, such as rehearsal strategy use, and generally in processes related to memory (Belmont & Butterfield, 1969; Ellis, 1970; Jarrold, Baddeley, & Phillips, 2002; Henry & MacLean, 2002). Research in the field of intellectual disability has also focused on attention difficulties. Specifically, according to research findings, children with intellectual disability usually exhibit difficulties in the effective processing of the task-relevant stimulus, mostly in cases with increased demands (Cha & Merrill, 1994; Tomporowski & Tinsley, 1997).

A major part of research studies in the field of intellectual disability, has attempted to approach and explain the potential of children with intellectual disability and the possibilities for enhancing this potential. Research findings showed that the use of memory strategies in children with intellectual disability seems to be enhanced, although strategy use remains less effective, when the appropriate support in the context of a task or setting is provided (Bray, Saarnio, Borges, & Hawk, 1994; Turner & Bray, 1985). Moreover, tasks based on external representation of the information are more likely to provide to children with intellectual disability opportunities to use strategies, rather than tasks that demand verbal-linguistic representation (Bray et al., 1994; Fletcher & Bray, 1995). Multiple examples presentation as well as understanding of task setting and task goals might have a positive effect on the performance of children with intellectual disability, although the generalization of the strategies that the children used is not certain (Ferretti, 1989). Other studies focus on the influence that the context might have on the performance of children with intellectual disability, at least in memory tasks (Carlin, Soraci, Dennis, Chechile, & Loiselle, 2001). Understanding of their memory skills could help children with intellectual disability improve their performance, although this is not an easy procedure, since they face difficulties in using metacognitive strategies (Borkowski, Reid, & Kurtz, 1984; Burack & Zigler, 1990). There is evidence

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that several students with mild to moderate intellectual disability have the potential to exhibit, to some extent, under certain circumstances and supported by the appropriate teaching practices, cognitive and metacognitive behaviors related to word problem solving tasks (Erez & Peled, 2001).

These research findings turn the attention, on the one hand, to the competencies of children with intellectual disability and not to their limitations or "deficiencies", and on the other hand to the possible ways for the enhancement and activation of their potential. The type of the experimental task, the nature of the cognitive strategy required in each case, the presence of external motivation or examples, as well as the mediation or not of language, constitute several factors that seem to have an influence on the cognitive performance of children with intellectual disability (Bray, Fletcher, & Turner, 1997; Fletcher & Bray, 1995; Fowler, 1998).

Among others, cognitive difficulties and competencies of every individual child should be taken into account in the planning of educational and teaching practices concerning children with intellectual disability. It is argued that educational discrimination and exclusion from general education classrooms regarding students with disabilities could be prevented by providing inclusion practices, appropriate curriculum adaptations and modifications and differentiated teaching and learning practices (Cook, Klein, Tessier, & Daley, 2004; Lawrence-Brown, 2004; Westwood, 2001). Moreover, knowledge about cognitive difficulties that students with intellectual disability usually face should be carefully used by teachers engaged in promoting inclusion of these children in general education. On the one hand, considering heterogeneity, not all children with intellectual disability are characterized by the same limitations in cognitive functioning. On the other hand, giving increased emphasis on "deficiencies" and weaknesses, rather than abilities and strengths of children's with intellectual disability cognitive functioning, could lead to misconceptions or ineffective treatment (Bray et al., 1997; Hodapp et al., 2003; Hodapp & Dykens, 2001).

Over the last decades, considering educational approaches to children with intellectual disability, researchers have emphasized the importance of bridging evidence on behavioural phenotype of several well known genetic syndromes associated with intellectual disability to specific adaptations in teaching practices (Fidler, Hodapp, & Dykens, 2002; Hodapp & Fidler, 1999). Several intervention models, that aim at providing access and enhancing participation of children with intellectual disability in general education programs, focus on promoting, through multilevel interventions, several critical skills which enhance self-determination development such as problem solving, decision making and critical thinking (Agran, Blanchard, Wehmeyer, & Hughes, 2002). According to Erez and Peled (2001), the planning of the educational program should facilitate the connection between cognitive domains, as well as transfer and generalization of knowledge, since children with intellectual disability have difficulties in transferring and generalizing knowledge and specifically in manifesting metacognitive behaviours. This issue entails the necessity of associating the academic knowledge provided in school settings with its application to everyday life of children with intellectual disability. Providing and promoting learning and the skills to be acquired in a more functional way, which is meaningful for the individual student, could enhance understanding and generalization of knowledge and in the long term could more effectively contribute to the improvement of the student's quality of life. In general, several teaching methods, such as community-based instruction, are taking into account these implications (Langone, Langone, & McLaughlin, 2000).

Teaching Science to Students with Intellectual Disability

The above mentioned evidence and implications present several challenges, regarding the selection of the appropriate methods, practices, and materials which would effectively support the teaching of science concepts to students with intellectual disability, and consequently their meaningful acquisition, specifically in inclusive educational settings. Considering the cognitive difficulties that characterize children with intellectual disability, there is a growing acceptance of the inappropriateness of using traditional teaching practices, which focus on the acquisition of exclusively academic skills through the use of text-books and through the oral presentation of the text-book content by the teacher.

Consequently, the criteria for choosing the appropriate teaching methods, that could aid children with intellectual disability acquire and apply knowledge related to science in a functional way, is a major issue for the teacher. Nonetheless, setting the instructional goals is an important aspect of organizing science teaching. As Banckroft (2002) suggested, the development of a specific methodology in order to plan and organize the appropriate educational material or to adapt the material according to the difficulties and competencies of children with intellectual disability, is a very important issue that could contribute to promoting access of those children to knowledge related to science. Moreover, the investigation and the understanding of the learning difficulties that the individuals with intellectual disability face in the process of acquiring new concepts related to science through teacher-directed methods that focus on text-book studying and oral presentation, is related to a change in teaching practices. Nowadays, there is a growing interest in using teaching practices that focus on learning through the action of the students themselves, such as student-directed learning, construction of knowledge, experimentation, connection to real life, provision of multi-sensory experiences and use of technology, taking always into account the need for adaptation of the above mentioned methods and practices to the student's individual needs (Salend, 1998).

Scruggs and Mastropieri (1995b) suggested that in the field of science education, as well as in other academic fields, there is an ongoing struggle between the advocates of teacher-directed learning (e.g. direct teaching through behavioural techniques) and learning based on constructivist principles through the active participation of the student (e.g. inquiry learning). Undoubtedly, considering science concepts, the principles of constructivism constitute an important proposition in forming related teaching practices. These principles usually emphasize the active role and self-regulation of students in the process of learning (Harris & Graham, 1994). On the other hand, the question about the appropriateness of implementing such methods based on constructivist principles and inquiry learning on teaching science concepts to students with mild to moderate intellectual disability, still remains.

Brooke and Solomon (2001) studied the usefulness of hands-on activities in a discovery setting, regarding science concepts learning by students with intellectual disability. According to the results of their study students with intellectual disability (e.g. Down syndrome), who were engaged in playing with the exhibits in an interactive learning center having enough time and with only a few instructions, showed a certain level of concentration, and even searched for the causes of the phenomena they observed. Moreover, the teachers observed that, although in the school context the same children performed certain activities associated with direct teaching practices, in the context of the interactive learning center, where their interaction with the exhibits was promoted, they seemed to develop curiosity and creativity.

On the other hand, the results of another study showed that inquiry learning based on inductive thinking strategy was ineffective for children with intellectual disability in comparison to children with typical development of the same chronological age (Mastropieri, Scruggs, & Butcher, 1997). Specifically, the researchers found that the students with mild intellectual disability (approximately 14 years old) that participated in an inquiry learning activity concerning pendulum length and motion, did not manage to draw the general rule, although they were provided with appropriately structured guiding steps and coaching. The researchers (Mastropieri et al., 1997) argued that a combination of inductive and deductive thinking strategies and developmentally appropriate activities and strategies might enhance learning in these children. In general, it is usually suggested that instructional strategies that might not facilitate learning for children with intellectual disability on inquiry learning tasks or activities, specifically in inclusive settings, need modification or adaptation. Mastropieri, Scruggs, Boon, and Carter (2001), underlined the significant effect of IQ on children's with intellectual disability performance on tasks related to science concepts learning in the context of inquiry learning. Specifically, the results of their study showed that children with mild intellectual disability had difficulties on tasks and activities that had been planned on the basis of constructivist principles and of the inquiry learning logic and aimed at acquiring basic physical science concepts, such as buoyancy. According to the above evidence, it becomes apparent that research on the effectiveness of several methods and strategies based on constructivist ideas and inquiry-based learning procedures that aim at acquiring science concepts by students with intellectual disability, yields a complex picture.

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An interesting approach in regard to the research evidence, which could inform educational practice in the field of science education, is the examination of the possibility of developing interventions and specific methods that might prove to be effective in enhancing thinking processes of children with intellectual disability, in order to develop their initial ideas about the world and about specific phenomena and conceptualize its possible change or impact. Undoubtedly, such an outcome is strongly influenced by the cognitive and metacognitive skills of the children with intellectual disability. Given the difficulties that children with intellectual disability face in information processing and moreover the particular cognitive profiles related to the cause of intellectual disability, the development of specified strategies in the context of science education is more than necessary.

Scruggs, Mastropieri, and Wolfe (1995), suggested that the cognitive and personality characteristics of the children with intellectual disability, as well as the educational value of the technique which is used regarding the study of the science concepts processing might be considered as possible factors that influence children's with intellectual disability performance on relevant tasks. Specifically, Scruggs et al. (1995) examined the preconceptions in regard to physical science concepts, such as the properties of air and electricity and the likelihood for scientific reasoning and change or differentiation of these ideas in children with mild intellectual disability (8 to 10 years old). The use of structured interview in combination with relevant experiences and materials as exemplars revealed that children with intellectual disability had certain initial ideas, although their relevant knowledge was insufficient or ambiguous. Moreover, the method researchers used, which was an empirical approach with a simultaneous use of structured questions, had a positive effect on the children's answers, but there was not sufficient indication of full understanding, which raises a point about the generalization of the knowledge acquired by the children.

Since cognitive limitations in problem solving and generalization of previous knowledge are usually related with difficulties in the learning process of children with intellectual disability, researchers have examined the possibility that cognitive strategy instruction might improve the children's performance and enhance their learning outcomes. In the field of mathematical problem solving, Chung and Tam (2005) found that cognitive strategy instruction, as well as worked example instruction, had a positive effect on children's with mild intellectual disability performance in comparison to conventional instruction. Scruggs et al. (1995, p. 242) argued that practicing of certain skills related to practices or methods in the field of science education, such as observation, comparison, inference etc., might contribute to enhancing the thinking skills of children with intellectual disability.

Current educational approaches suggest that inquiry-based science instruction promotes the deeper understanding of science ideas and concepts, as well as scientific reasoning. This assumption yields certain important challenges regarding science instruction in inclusive settings. Two specific issues related to these challenges is choosing and adapting the practices that could enhance learning for students with intellectual disability, with respect to the demands of inquiry-based learning, as well as providing the appropriate support to them in order to respond efficiently to these demands.

Implementation of peer assistance in the context of inquiry learning has been suggested as a successful method for facilitating students with mild intellectual disability to process science activities, although facilitation of scientific reasoning was far more difficult (Scruggs & Mastropieri, 1995a). Moreover, it is argued that cooperative learning could be successfully implemented in science instruction to students with intellectual disability. In a pilot study (Farlow, 1994), concerning children with moderate to severe intellectual disability, cooperative learning has been shown to be an efficient method for promoting children's communication skills and for increasing the opportunities for content knowledge in a biology class (p. 18). Nonetheless, the use of educational technology and multimedia could also contribute to science instruction. Research evidence, at least in self-contained classrooms, suggests that students with intellectual disability could successfully participate in science instruction, in the context of inquiry-oriented activities, given the appropriate adaptations or modifications that effectively address their cognitive or personality characteristics, such as reasoning, attention difficulties, memory for verbal information, outerdirectedness, which usually interact with inquiry learning demands (Scruggs & Mastropieri, 1995a).

Future research studies in inclusive school settings, should empirically verify the effectiveness of the instructional and learning strategies and methods that seem to promote successful engagement of stu-

dents with intellectual disability in inquiry-based science instruction, as well as successful acquisition and generalization of science knowledge (Mastropieri et al., 2001). Mastropieri, Scruggs, Mantzikopoulos, Sturgeon, Goodwin, and Chung (1998), investigated inclusive science teaching with respect to the instructional methods that could affect the students' with disabilities (intellectual disability among others) achievement, as well as the performance differences between students with disabilities and their peers without disabilities. The research findings suggested that activities-based instructional approach implemented in an inclusion classroom had a positive influence on the students' with disabilities participation and performance, compared to the textbook-based approach. The students' with disabilities performance was equivalent to that of their inclusion classroom peers and they outperformed most of their peers without disabilities in the regular classrooms, where instruction of the same science unit was based on text-book. Inclusive science teaching is a multidimensional field, which, given the flexibility of the general educational program goals, is influenced at least by individual variables, such as the students' characteristics and the teacher's preparation and readiness to implement differentiated instruction and motivate students, as well as by environmental variables such as the educational material available and the organization of the teaching context.

Science instruction to students with intellectual disability, with respect to activities-based learning, could provide them with valuable knowledge about the world and improve their successful functioning into the real world that surrounds them. On the other hand, it could constitute an important pathway for the enhancement of their problem solving skills (Scruggs et al., 1995). These gains are strongly associated with the educational and learning context, within which activities-based science teaching is provided. There is also a strong relation of those benefits with the methods and strategies with which science learning is approached and provided. Further research, based on longitudinal studies and empirical data, could provide additional evidence on the appropriateness and effectiveness of teaching methods based on specific activities, such as those related to inquiry-based instruction. In any case, the heterogeneity that characterizes the field of intellectual disability should be considered.

Discussion

Current perspectives in educational program and intervention planning emphasize functional academic skills teaching rather than conventional academic skills teaching, considering the limitations that characterize people with intellectual disability in information processing and in adaptive behavior. Moreover, learning for people with intellectual disability seems to be inhibited in the context of traditional text-book and lecture-based instruction rather than facilitated (Mastropieri et al., 1998). Specifically, strictly academically oriented curricula in combination to the implementation of text-book and lecture-based teacher-directed teaching methods do not seem to facilitate the development of the children's with intellectual disability cognitive and social functioning. The development of functional skills in an educational context could eventually contribute to their community inclusion and in certain cases independent living (Brolin & Loyd, 2004; Cronin & Patton, 1993).

Generally, it would be suggested that science education, regarding students with intellectual disability, could involve a combination of teacher-directed and student-directed learning practices, considering, in any case, information about the learning and behavioral characteristics of the individual student. Information based on the appropriate assessment of the student's difficulties and competencies could be utilized in specifying the necessary adaptations or modifications during the learning process. Such a suggestion is undoubtedly very general, since research findings on the effectiveness of specific strategies and methods used in science instruction to students with intellectual disability reveal a complex picture. On the one hand, there is evidence that hands-on activities and inquiry-oriented science instruction benefit students with intellectual disability, in comparison to textbook-oriented and lecture-based instruction (Mastropieri et al., 1998). On the other hand, although there is some evidence that students with mild intellectual disability could benefit from inquiry-oriented approaches, that rely on guided and structured coaching and specific adaptations with respect to students' cognitive difficulties (Scruggs & Mastropieri, 1994), there is also evidence that inquiry learning based on constructivist principles and inductive reaso-

ning approaches do not effectively promote learning and generalization in children with intellectual disability, at least in the context of specific science tasks and learning procedures (Mastropieri et al., 2001).

These findings quest for empirical verification and further investigation is also needed in order to bring to light the learning procedures and the appropriate adaptations that could reduce the learning and generalization difficulties that students with intellectual disability face in inquiry-oriented science tasks. Another important issue has to do with the effectiveness of these methods and instructional practices in the context of inclusion settings.

Science education regarding students with intellectual disability presents certain challenges. Since intellectual disability is characterized by heterogeneity, it would be very interesting to have further evidence in regard to people with different causes of intellectual disability. For example, future research could provide additional information on science instruction planning by taking into account the particular cognitive-linguistic and personality profiles of persons with different genetic syndromes associated with intellectual disability, as well as the knowledge about the adaptations and intervention practices which are usually proposed as appropriate in relation to those persons' difficulties and competencies (Hodapp & Fidler, 1999).

The successful implementation in different educational settings of specific methods and practices in science education for students with intellectual disability, as well as the development of appropriate adaptations, in accordance to the students' difficulties and competencies, has a direct relation to the special education teacher's training and preparation (Scruggs & Mastropieri, 1995). Moreover, the knowledge and information provided to the special education teacher, concerning theoretical approaches to intellectual disability and research evidence on cognitive and behavioral characteristics of people with intellectual disability, as well as the existence of well informed assessments of the persons' with intellectual disability difficulties and competencies, could have a critical influence on the development of appropriate adaptations and teaching practices.

Cognitive and metacognitive difficulties related to thinking processes, with which people with intellectual disability usually deal, as well as their personality characteristics related to motivation factors, pose certain critical questions regarding the adequate choices about the content, goals, materials, methods and practices and the learning procedures in science teaching to students with intellectual disability. Choosing the appropriate instructional methods and practices should be directly associated with the needs, the limitations and the potential of every individual student with intellectual disability. Actually, in the process of intervention planning not only the cognitive limitations of the children with intellectual disability should be emphasized, but their potential as well. Educational interventions could be informed by their competencies rather than be restricted to their difficulties (Hodapp et al., 2003; Hodapp & Dykens, 2001). Dealing with the weaknesses of a child with intellectual disability and even more with his or her cognitive difficulties, instead of facing the child with intellectual disability as a person not determined only by his cognitive difficulties, might limit the benefits that inclusive education could offer.

Scruggs et al. (1995, p. 242) argued that at least certain aspects of science education could have a critical value in everyday lives of children with intellectual disability. The connection of academic content to real life experiences, as well as community-based instruction, have had in most cases a positive impact on learning and new skills acquisition by children with intellectual disability (Cihak, Alberto, Kessler, & Taber, 2004). Consequently, it is suggested that science concepts and knowledge could be taught in the context of a functional curriculum. Specifically, under the perspective of differentiated instruction and functional skills acquisition, knowledge about the real world and management of the related positive and negative challenges, as well as the acquisition of relevant critical functional skills, could be promoted in the context of science education.

Further research is needed to provide evidence concerning the effective practices in science teaching to students with intellectual disability. Studying the implementation of relevant practices in real inclusive settings could contribute to bridging research to practice, which is a very critical issue in the field of education for people with intellectual disability.

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