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Can Designing Self-Representations through Creative Computing Promote an Incremental View of Intelligence and Enhance Creativity among At-Risk Youth?

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Abstract

Creative computing is one of the rapidly growing educational trends around the world. Previous studies have shown that creative computing can empower disadvantaged children and youth. At-risk youth tend to hold a negative view of self and perceive their abilities as inferior compared to "normative" pupils. The Implicit Theories of Intelligence approach (ITI; Dweck, 1999, 2008) suggests a way of changing beliefs regarding one's abilities. This paper reports findings from an experiment that explores the impact of a short intervention among at-risk youth and "normative" high-school students on (1) changing ITI from being perceived as fixed (entity view of intelligence) to more flexible (incremental view of intelligence) and (2) the quality of digital self-representations programmed though a creative computing app. The participants were 117 Israeli youth aged 14-17, half of whom were at-risk youth. The participants were randomly assigned to the experimental and control conditions. The experimental group watched a video of a lecture regarding brain plasticity that emphasized flexibility and the potential of human intelligence to be cultivated. The control group watched a neutral lecture about brain-functioning and creativity. Following the intervention, all of the participants watched screencasts of basic training for the Scratch programming app, designed artifacts that digitally represented themselves five years later and reported their ITI. The results showed more incremental ITI in the experimental group compared to the control group and among normative students compared to at-risk youth. In contrast to the research hypothesis, the Scratch projects of the at-risk youth, especially in the experimental condition, were rated by neutral judges as being more creative, more aesthetically designed, and more clearly conveying their message. The results suggest that creative computing combined with the ITI intervention is a way of developing creativity, especially among at-risk youth. Increasing the number of youths who hold incremental views of intelligence and developing computational thinking may contribute to their empowerment and well-being, improve learning and promote creativity.

Keywords: creative computing, creative coding, creative programming, scratch application, implicit theories of intelligence, constructionism, at-risk youth, normative high-school students

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Introduction

One of the prominent trends in recent years, in relation to the use of educational technologies in formal and informal learning environments for children and youth around the world, is called "creative computing" (Yang & Zhang, 2016), "creative coding" (Bergstrom & Lotto, 2015) or "creative programming" (Park, 2016).

Creative computing is not a new idea, but rather, the refinement of a previous approach that was abandoned. Learning programming tools like Basic, Logo, and Pascal were widespread educational systems in the 1980s (Papert, 1980), but were discarded in the 90s with the rise of the Internet (Kafai & Burke, 2015). Today, efforts are being invested in designing apps that enable the construction of digital artifacts with a minimum requirement of prior programming knowledge. Contemporary programming applications, such as Scratch Online, Planet Kodu, CodeMonkey, Alice, Newgrounds, Looking Glass, and EJS, encourage young people to program, not as a way of learning programming per se, but rather, as an opportunity to create and share their ideas and digital artifacts with other users through the network (Brennan & Resnick, 2012; Zuckerman, Blau, & Monroy-Hernández, 2009). Indeed, to emphasize this point we have chosen to use the term "creative computing" in our paper rather than coding or programming. These current applications effectively combine programming learning with participation in an online community and allow teens to create and share their interactive projects, ranging from digital storytelling, simulations, and games, to programmable digital clothes (Brennan, Chung, & Hawson, 2011; Kafai & Burke, 2015). Resnick, the head of the MIT Media Lab, who developed the Scratch app (http://scratch.mit.edu/) used in our study, claimed that this technology teaches children to be creative and to think in a structured and collaborative way (Flanagan, 2015). However, based on a review of 27 available intervention studies, Lye and Koh (2014) called for more K-12 intervention studies centering on computational practices and the computational perspectives of students.

This paper reports findings from an experiment among at-risk youth and "normative" high-school students that explores the impact of a short creative computing intervention on their perception of intelligence as either fixed or incremental and on the quality of digital self-representations programmed though a creative computing app.

Frameworks and Literature Review

The theoretical framework underlying this trend of creative computing is a learning approach called *Constructionism* (Papert, 1980). According to this learning theory, people learn more effectively while creating tangible outcomes, both physical environments and digital artifacts. This approach emphasizes the importance of facilitating students' use of technology as 'building material' to create digital outcomes or artifacts. Papert claimed that in the process of creating these outcomes, over time, digital devices become 'objects to think with'; they enable students to learn how to learn and how to solve problems.

The learning experiences offered by creative computing applications are in line with recent arguments on the importance of developing *computational thinking,* the use of concepts from the domain of computer science and programming to solve problems in other domains (Sharples et al., 2015). The term, "computational thinking" was initially used by Papert (1996) in order to emphasize the inherently interdisciplinary nature of computing and its potential to engage learners in new ways of thinking. Thus, the goal of designing computational artifacts is not to prepare future programmers, but rather to develop computational thinkers who can confidently cope with complexity and with open-ended problems and transfer computational perspectives across contexts and disciplines (Grover & Pea, 2013; Sharples et al., 2015; Wing, 2006). According to Sharples and colleagues (2015), when dealing with a variety of problems, computational thinking involves internalization of the following steps: decomposition of a large problem into smaller ones, recognition of patterns used in the past to solve these problems, identification of unimportant details and setting them aside, designing and refining the steps necessary to reach a solution, debugging these steps, and presenting a solution in a usable form.

Moreover, creative computing is an important design activity which gives youth a real opportunity to '*learn by design*' and to build important 21st century digital literacy competences within the context of a complex design project (Blau & Shamir-Inbal, 2016; Brennan & Resnick, 2012). Instead of technical details of computation, creative computing emphasizes the interests of youth, their vivid imagination, and the realization of their creative potential (Benolol & Blau, 2016; Blau, Zuckerman, & Monroy-Hernández, 2009; Kafai, 2016). It helps in developing competences and literacies that youth need to become producers and designers of dynamic media and interactive digital outcomes and that they can enjoy on a daily basis (Blau & Peled, 2015; Eshet-Alkalai, 2012; Park, 2016; Shamir-Inbal & Blau, 2014, 2016a, 2016b). Although the importance of 'learning by design' is widely accepted (Kafai & Burke, 2014, 2015; Ke, 2014; Peppler & Kafai, 2007), school students have little experience in following the design process from beginning to end, which involves researching, planning, problem-solving, dealing with time constraints, modifying expectations, and bringing different parts of the project together (Kafai, 2016).

One of the populations that may especially benefit from creative computing is *at-risk youth.* Previous studies have shown (Benolol & Blau, 2016; Mahiri 2011; Parker 2008; Peppler & Kafai, 2007; Watkins, 2009) that creative computing can improve the self-esteem of children and youth who are disadvantaged for demographic reasons, such as their ethnic origin, cultural background, or socio-economic status. In the education system, at-risk youth are often marginalized and are characterized by academic failure, violent behavior, and lack of involvement in school activities (Blau & Barzel-Rubin, 2013; Dishion, Véronneau, & Myers, 2010). As a result of rejection, at-risk youth develop a negative view of the self (McWhirter, McWhirter, McWhirter, & McWhirter, 2003). Resnick and Burt (1996) presented a conceptual framework that suggests four main components of "risk" among youth: (1) risk antecedents such as poverty, a delinquent social environment, and a dysfunctional family; (2) risk markers, such as dysfunction in school, including explicit or hidden dropout, and involvement in delinquent activities; (3) risk behaviors – frequent absences from school, frequently running away from home, sexual relationships at a young age, as well as early smoking, alcohol, and drugs use; (4) risk outcomes – early pregnancy and parenthood, homelessness, involvement in prostitution, drug and alcohol abuse, involvement in criminal activities, dropping out of the education system and local community, and disconnecting from them. These adolescences may feel that they belong neither to an interpersonal or social circle, and that they are not capable of adapting to either. The absence of social contact and engagement with social institutions results in low self-esteem, identity disorders, and a sense of alienation from society, its values and its institutions (Mekamel & Blau, 2014, 2016; Snyder, 2004).

One way to improve the self-perception of at-risk adolescents may be related to changing their perceptions regarding their intelligence. *Implicit Theories of Intelligence* (ITI; Dweck, 1999, 2008; Dweck, & Leggett, 1988) focuses on the human perception of intelligence as fixed or flexible and growing. According to this approach, the perceptions of people regarding their intelligence lie on the continuum between the perception of intelligence as fixed and unchanging throughout life (entity view of intelligence) and the concept of a flexible, evolving intelligence (incremental view). Empirical studies have shown that the perception of intelligence held by young participants creates a framework for the interpretation of events in their lives, and thus determines their behavior (Yeager, Trzesniewski, & Dweck, 2013).

Although both (entity and incremental) ITI are equally prevalent in the population and are typically stable over time and do not vary, either by gender (Robins, & Pals, 2002), or across national, ethnic or racial groups (Yeager et al., 2013), findings have shown that they can be influenced by specific teaching strategies through a short and simple intervention (Blackwell et al., 2007; Dweck & Master, 2008). In Blackwell et al.'s (2007) study, the experimental group received explanations regarding brain changes demonstrating that intelligence is flexible and can be developed. After this short intervention, the participants in the experimental group endorsed an incremental intelligence view more strongly than the participants in the control group who received neutral explanations regarding brain functioning. Adaptation of this intervention for changing students' ITI to a more incremental view was also successfully replicated in a different context, which led to changes in the participants' desire for vengeance in a social situation (Yeager et al., 2013). Half of the participants read a brief story about a student who was a victim of bullying in school, who learned from peers and adults that people's characteristics are changeable. Adolescents who received this incremental theory message, compared to those who read the same scenario without it, were significantly more likely to choose pro-social conflict solutions, such as explaining to the aggressors the effects of their actions, instead of choosing aggression against the bullies.

Research Goals and Hypotheses

The purpose of this study was to examine the possibility of transforming Implicit Theories of Intelligence regarding one's abilities from fixed (entity view) to more changeable (incremental view) among at-risk youth and normative students through the creation of programming representations of themselves in the future. The study also explored how the intervention to change ITI impacts the quality of digital artifacts: the clarity of conveying the represented idea, the quality of the programming, the creativity and originality of the artifact, as well as the aesthetics of its design.

The research hypotheses are:

1. Incremental *Implicit Theories of Intelligence* will be higher in the experimental group than in the control group, and among normative students compared to among at-risk youth. This is based on the ITI theory (Dweck, 1999, 2008) and previous findings showing that at-risk youth develop a negative view of the self (McWhirter et al., 2003). Additionally, we hypothesized that an interaction effect will be found between the type of participants and the experimental condition, so that the empowerment of at-risk youth through an incremental view of intelligence will be stronger in the experimental group.
2. Regarding *the quality of the creative computing* of self-representations in the future, we hypothesized that for four parameters of creative programming though the Scratch platform (clarity of the idea, quality of programming, creativity and originality, and aesthetics of the design), we will find that the quality of the normative students' digital artifacts will be rated as higher compared to that of the at-risk youth, and participants in the experimental group higher than participants in the control condition. Also, we hypothesized that an interaction effect would be found between the two variables, so that the quality of projects created by at-risk youth will be higher in the experimental group compared to all other groups following the manipulation of change in Implicit Theories of Intelligence.

Method

Participants

The participants were 117 youths from central Israel, 62 (53%) of whom were male. All of the participants were high school teenagers (Range: 14-17, Average: 14.98, SD: 0.73, Median and Mode: 15, Skewness: 0.232). Among the participants, 61 (52%) were at-risk youth who had dropped out of the education system; these participants were recruited from a special educational institution, which was designed for these teenagers as a substitute for formal schooling and which they attended as part of an at-risk youth program. The remaining participants were high school students who, for research purposes, were defined as “normative students”. School students with learning disabilities were excluded from the analysis.

The at-risk and “normative” participants were randomly assigned to experimental or control groups. The Scratch application for creative computing was new to all of the participants in the experiment.

Instruments and Procedure

Participants in both groups watched a short videotaped lecture related to brain activity. While in the experimental group the video highlighted the possibility for intelligence to change and evolve (Blackwell et al., 2007), the control group watched a neutral lecture about brain-functioning and creativity. After the intervention, both groups were asked to create a project using a creative computing application, Scratch, through which the participants were asked to present the way they see themselves in five years’ time. This instruction was inspired by previous findings regarding the importance of purpose in life for the wellbeing of adolescents in general (Damon, 2008; Heng & Blau, 2016) and disadvantaged adolescents in particular (Mariano, Going, Schrock, & Sweeting, 2011). In order to learn the basics of using the Scratch application, all participants watched the screencast tutorial explaining the basics of creative computing on Scratch before beginning to work on the project. These screencasts were developed by the Israeli Ministry of Education for educational purposes unrelated to the research.

Participants’ digital self-representations were saved and analyzed according to the following parameters: (1) clarity of the project’s idea (i.e., how clear it is to the viewer where the participant sees him or herself five years later), (2) quality of computing, (3) creativity and originality of the artifact, and (4) aesthetics of the design. These parameters were determined by the researchers after consultation with two experts in the field of creative computing. The programming quality of the projects was examined using an assessment applet on the Dr. Scratch website (http://drscratch.programamos.es/) on a scale from 1 to 11. The rating of the three other parameters mentioned above was performed on a scale ranging from 1- very slightly to 5- very much by a research assistant unaware of the research hypotheses. Out of all of the projects, 25% were independently rated by a second judge, and the degree of agreement between judges was good (Cohen’s Kappa range for various parameters κ=.86-.89).

After the participants finished working on the projects, they filled out a self-report questionnaire that included the Implicit Theories of Intelligence Scale (Dweck, 1999; Dweck & Henderson, 1988) and demographic data. The ITI scale is composed of three items: “You have a certain amount of intelligence, and you really can’t do much to change it”, “Your intelligence is something about you that you can’t change very much”, “You can learn new things, but you can’t really change your basic intelligence”. Agreement with each item indicates an entity view, while disagreement signifies an incremental view of intelligence. The report was on a scale from 1- strongly disagree to 6- strongly agree. Internal consistency reliability between the three statements was good, α=.82.

Note that we did not examine intelligence beliefs at baseline, since this was a relatively short experiment and, in addition to the demographic data, the self-report questionnaire the Implicit Theories of Intelligence Scale consists only of three items. Hence, if the ITI scale would have been administered twice, our participants could easily have remembered their ratings at baseline. One of the assumptions of experimental research design is that random assignment of participants to experimental conditions neutralizes differences between the groups; therefore we decided to only administer the ITI scale after the experiment.

Table 1 presents descriptive statistics for the dependent variables in the study – Implicit Theories of Intelligence and the four assessment parameters of the Scratch projects.

Table 1: Descriptive statistics for dependent study variables

		Assessment of Scratch self-representations			
	ITI	Clarity of the project's idea	Quality of programming	Creativity/Originality of the project	Aesthetics of the design
Average	3.95	3.74	3.46	3.01	2.96
Median	4	4	2	3	3
Mode	3	5	1	3	2
SD	1.33	1.36	2.84	1.13	1.20
Skewness	-0.332	-0.634	0.776	0.200	0.053
SE of skewness	.226	.224	.228	.224	.224
Minimum	1	1	1	1	1
Maximum	6	5	11	5	5

As shown in the table, the variables Implicit Theories of Intelligence, creativity and originality, and aesthetics of Scratch projects design, were normally distributed. In contrast, the clarity of the project's idea parameter is slightly tilted towards positive values, whereas the quality of the programming parameter is tilted towards lower values. In other words, the project idea was conveyed quite clearly, while the quality of programming was assessed as quite low (note that these are the projects of new users who were exposed to creative computing for the first time).

The research procedure was approved by the Institutional Ethics Committee. The experiment was conducted during the spring of 2015. The length of the procedure was two hours. At-risk youth carried out the experiment in the computer lab at the institution they attended as part of an at-risk youth program. Normative students participated in the experiment in the computer lab at their school. During the study, one of the researchers and one of the research assistants were present. The projects were saved on a portable disc for analysis and were not uploaded to the Scratch community website because of ethical considerations and in order to maintain the anonymity of the participants. Participants' self-report of ITI and the quality parameters of the digital self-representations were analyzed using the SPSS22 program.

Results

Implicit Theories of Intelligence

Table 2 presents descriptive statistics for the ITI measure according to the experimental condition and participant type – at-risk youth versus normative students.

Table 2: Descriptive statistics for ITI by experiment groups and type of the participants

Type of group	Type of participants	Average	SD	N
Experimental group	Normative students	4.37	1.35	28
	At-risk youth	3.96	1.55	29
	Total	4.16	1.46	57
Control group	Normative students	4.00	1.10	27
	At-risk youth	3.51	1.18	31
	Total	3.74	1.16	58
Total	Normative students	4.19	1.24	55
	At-risk youth	3.73	1.38	60
	Total	3.95	1.33	115

Results of a two-way ANOVA showed marginally significant differences in ITI, with participants in the experimental group perceiving intelligence as more changeable than participants in the control group ($F_{(1,113)}$=2.97, p=.08, η^2=.03). The main effect of the participant type was also marginally significant – normative students perceived intelligence as more malleable than at-risk youth ($F_{(1,113)}$=3.34, p=.07, η^2=.03). The acceptable effect sizes of both factors suggest that the tests might not have reached statistical significance because of the relatively small number of participants. No significant interaction effect was found between those two factors.

Assessment of the Scratch Project Parameters

Four ANOVA tests with the experimental condition and participant type as between-subjects variables were performed in order to examine the differences in the parameters of the digital projects, in which the participants symbolically represented themselves five years later using the Scratch creative computing environment. Table 3 shows the results of the descriptive statistics for the four tested parameters which measured the project quality.

Table 3: Average and SD values for projects parameters for at-risk and normative students

	Experimental group M (SD)			**Control group M (SD)**			**Total M (SD)**	
Parameters	Normative students	At-risk youth	Total	Normative students	At-risk youth	Total	Normative students	At-risk youth
Clarity of the idea	3.69 (1.47)	4.00 (1.08)	3.84 (1.28)	3.22 (1.57)	3.97 (1.22)	3.62 (1.44)	3.47 (1.52)	3.98 (1.15)
Quality of programming	3.62 (2.60)	3.60 (3.19)	3.61 (2.89)	3.81 (2.74)	2.81 (2.84)	3.30 (2.81)	3.71 (2.64)	3.23 (3.02)
Creativity and originality	2.76 (1.35)	3.43 (0.90)	3.10 (1.18)	2.74 (1.06)	3.06 (1.09)	2.91 (1.08)	2.75 (1.21)	3.24 (1.01)
Aesthetics of the design	2.62 (1.12)	3.63 (0.81)	3.14 (1.09)	2.92 (1.41)	2.64 (1.17)	2.78 (1.28)	2.77 (1.26)	3.13 (1.12)

Regarding the *clarity of the idea*, the analysis of variance showed a significant main effect for the participant type, in which, contrary to the hypothesis, at-risk youth were able to convey their project idea in a more comprehensible way than normative students ($F_{(1,113)}$=4.51, p=.036, η^2=.04). The experimental group effect and the interaction effect were not statistically significant.

For the *quality of programming* parameter, no significant difference was found between any of the groups.

As for the *creativity and originality* parameter, the analysis of variance showed a significant main effect for participant type. Contrary to the research hypothesis, the at-risk youth's projects were rated as significantly more creative than those of the normative students ($F_{(1,113)}$=5.88, p=.017, η^2=.05). The main effect for the experimental condition was not significant, but a significant interaction effect was found between the two factors ($F_{(1,113)}$=2.50, p=.048, η^2=.03). Namely, in the experimental group the at-risk youth's projects were rated as more creative than those of the normative students, while no difference in creativity was found between at-risk youth and normative students in the control group.

Concerning the *aesthetics of the design*, the analysis of variance showed a significant main effect for participant type: contrary to the research hypothesis, the design of the at-risk youth's self-representations was rated as significantly more aesthetic than that of the normative students

($F_{(1,113)}$=3.01, p=.038, η^2=.03). The main effect of the experimental group was not significant, but a significant interaction effect was found between the two factors ($F_{(1,113)}$=9.40, p=.002, η^2=.08). While in the experimental group at-risk youth created more aesthetic projects than normative students, no difference was found between at-risk youth and normative students in the control group.

Discussion and Conclusions

This paper examined change in perceptions of intelligence among at-risk youth and normative students in the context of a creative computing environment. Consistent with *the first research hypothesis* and similarly to previous studies (Blackwell et al., 2007; Yeager et al., 2013), we found that short and quite simple training can change Implicit Theories of Intelligence: youth can perceive intelligence as less fixed and more changeable and are able to evolve. As expected based on previous conceptualizations (Resnick & Burt, 1996) and findings regarding the characteristics of at-risk youth (Dishion et al. et al, 2010; McWhirter et al., 2003), the findings of the study indicated that they held a more fixed view of intelligence compared to normative students of the same age. However, contrary to the hypothesis, no interaction effect was found between the participant type (at-risk/normative) and the experimental condition.

As for creative computing, in contrast with *the second research hypothesis*, the findings showed a consistent advantage of at-risk youth over normative students. Namely, they were able to convey the idea for their digital self-representations more clearly and to create Scratch projects that were rated by a rater, who was unaware of the research hypotheses, as more creative and aesthetic. It therefore seems that, consistent with previous studies on the empowerment of youth who are disadvantaged as a result of socio-economic status or various demographic variables (Mahiri, 2011; Parker, 2008; Peppler & Kafai, 2007; Watkins, 2009), creative computing provides at-risk youth with an alternative channel to express their creativity and originality.

Moreover, in accordance with the second research hypothesis, the interaction effect between two factors indicated that in relation to quality parameters, such as the originality of the Scratch project and the aesthetics of its design, the advantage of at-risk youth over their normative peers is found only in the experimental group – after the intervention to change the Implicit Theories of Intelligence. Thus, it seems that the empowerment of students in general and at-risk youth in particular through creative computing is more effective when combined with training that emphasizes the ability of human intelligence to evolve (Benolol & Blau, 2016).

Implications and Future Work

The at-risk youth who study in special institutions are in an extremely complex situation. Many of them are not equipped with the necessary competences to succeed and advance on their own and are in need of guidance and support. Moreover, many of them do not have any appropriate role models in their close surroundings, and some find themselves lacking the basic trust in the people surrounding them and in their own abilities and potential to succeed in the future. At-risk youth need support and guidance along the way, so that they can utilize the tools that are being offered to them. Thus, to make learning effective for these students, we need to address their creative potential.

This pioneering research aimed to empower at-risk students by combining the potential of creative computing for this population reported in some projects led by the MIT research group, with an ITI intervention, which provides at-risk youth with a hope that despite their past, they can dream big dreams and have a desirable future. And indeed, this study shows that empowerment through an ITI intervention combined with creative computing allowed at-risk youth to express their creative potential beyond that of so called normative students. Future intervention projects among at-risk youth with greater and more extensive experience of designing tangible digital representations of a better future through creating computing can contribute to empowerment of this disadvantaged population.

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Biographies

Ina Blau is a Senior Lecturer in the Department of Education and Psychology, at The Open University of Israel. She has a PhD. in E-Learning and Cyber-Psychology. In 2011-2014 she was a lecturer in the Department of Information & Knowledge Management, Graduate School of Management, University of Haifa, and in 2015 - a Visiting Scholar at the National Institute of Education (NIE) and Learning Sciences Lab, Nanyang Technological University (NTU), Singapore. Dr. Blau has diverse experience in teaching, educational management, and teacher's professional development related to technology-enhanced teaching and e-learning. Her research interests and publications focus on social aspects of e-communication and e-leadership; integration of innovative technologies in K-12, academia and organizations; mobile learning and interaction; digital literacy skills; the effect of "productive failure" experience on the development of creativity; psychological ownership in e-collaboration and online privacy in social networking. She has led large-scale research projects which were supported by research grants from the Israeli Ministry of Education and focused on the phenomenon of digital cheating and plagiarism from the perspective of Israeli pupils, teachers and parents, and on processes and outcomes of one-to-one computing in schools.

Nurit Benolol is a lecturer at Beit Berl College in Kfar Saba, Israel. She completed her Bachelor's degree in Education at Beit Berl as well as her teaching certificate, with a focus on the social sciences. She completed her Master's degree in Educational Consulting at Bar Ilan University, writing her thesis on the influence of therapeutic intervention through sport under the supervision of Dr. Shlomo Romi. She proceeded to complete her doctorate at Bar Ilan, writing her thesis on the topic of "The role of personal and social capital in the adjustment of youth at risk, in the transition to young adolescence" under the supervision of Prof. Shmuel Shulman. She currently teaches in the Department of Criminology at Beit Berl College. Dr. Benolol has rich professional experience and serves as an Educational Consultant in the educational system for the last 20 years. In her private practice she uses cognitive behavioral therapy to help children and youth with functional difficulties.