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Meta-cognitive knowledge, locus of control and understanding mathematical jokes: A study in students with and without learning disabilities

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This study examined how metacognitive knowledge and locus of control are associated with understanding mathematical jokes in students with and without learning disabilities. This study looked at a sample of 60 ninth-grade students of which 30 had a learning disability diagnosis and 30 had no learning disabilities. Students were tested using three instruments: a metacognitive knowledge questionnaire, a locus of control questionnaire, and a questionnaire to gauge understanding of mathematical jokes. The results point to a significant correlation between these three variables. Students with learning disabilities presented lower performance on all measures compared with students without learning disabilities. In view of the marked gaps between the two populations of students, it is important to support students with learning disabilities in the areas of metacognitive knowledge and locus of control. This may help improve their academic achievements in mathematics and other school subjects, and may have a beneficial effect on their social interactions and on dropout rates.

Key words: Metacognitive knowledge, Locus of control, Mathematical jokes, Learning disabilities

INTRODUCTION

Brain science is highly interested in understanding metacognitive knowledge and locus of control as part of the neurological system. Metacognitive knowledge refers to higher-level thinking about thinking: planning, understanding, and evaluating, as well as awareness of thinking processes and strategies. Locus of control refers to the degree to which people perceive themselves to be in control of situations. People with an internal locus of control believe that they have control of situations and can affect outcomes, whereas people with a more external locus of control believe that things outside their control like luck, destiny, and hardship determine the outcome of situations they are facing (Abouserie, 1994).

Both metacognitive knowledge and locus of control have been shown to play a potential role in mathematics achievement and to be predictors of problem-solving abilities (Chytrý et al., 2020; Villa and Sebastian, 2021). On the teachers' side, using mathematical jokes in class

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is an effective teaching strategy: first, because students learn the mathematics they need to understand the jokes, and second, because class atmosphere improves with reduced tension and better communication between teacher and students (Tonkovich, 2020).

This study aimed to examine the associations between metacognitive knowledge, locus of control, and ability to grasp mathematical jokes that are told in mathematics classes in students with and without learning disabilities. Researchers of mathematical education agree that metacognitive knowledge and locus of control come into play in today's fast-changing environment, which requires people to learn independently and constantly adapt to new learning tasks (Chytrý et al., 2020). The ability to think critically and solve problems creatively lies at the foundation of learning mathematics. Unfortunately, mathematics is far from easy for many students (Villa and Sebastian, 2021).

By understanding the associations between metacognitive knowledge, locus of control and ability to grasp mathematical jokes used in mathematics classes in students with and without learning disabilities we may be able to benefit students in two ways. First, by better design of mathematics curricula for all students, and second, by pinpointing existing obstacles in the educational system, and discovering suitable interventions for students with learning disabilities who are struggling with mathematics.

Metacognition

Over the past few decades, metacognition has gained the attention of scientists in educational research. Flavell (1976) coined the term in his discussion of metacognition as people's self-awareness of their own cognitive processes. Metacognitive knowledge is composed of the one's knowledge of oneself, the components of the tasks one need to perform, which need to be addressed before performing them, and the cognitive strategies required in order to perform the tasks. As such, metacognition can be viewed as a cognitive supervisory system (Garrett et al., 2006; Kramarski and Mizrachi, 2006).

Individual learners vary in personality traits, perceived self-efficacy and subjective awareness of weaknesses, motivation, world-view based on knowledge, and more. Lack of knowledge about self could inhibit learning, because learners who are unable to identity their own strengths and weaknesses will find it difficult to regulate their learning processes and adapt effectively to different situations. In addition to this, the cognitive process is accompanied by internal experiences, and these too require awareness, which contributes to metacognitive knowledge and self-direction (Garrett et al., 2006). Knowledge of a task includes evaluating its level of difficulty and finding the appropriate cognitive strategy is requires (Kramarski and Mizrachi, 2006). For example, students who have difficulty with retrieval may find it harder to take exams that are memory-based compared with multiple-choice exams. Knowledge of the strategy required to perform a task means the learner's awareness of effective cognitive and metacognitive strategies that should be used for the specific task, familiarity with them and the way they are applied (how, when, and why). Accordingly, a learner examines the nature of the task in question and chooses a suitable strategy (Martini and Shore, 2008).

According to the literature, self-regulation of cognitive processes is a central feature of metacognition. Self-regulation, in this sense, is a process in which learners are responsible for their own development and in which they apply thoughts, feelings, and actions to achieve the desired end (Zimmerman, 2000, p. 14; Perels et al., 2009).

Studies have found that feelings are significant predictors of self-directed learning and achievements (Ahmed et al., 2013; Mega et al., 2014). According to Zimmerman (2000), increased anxiety and lower self-efficacy may derail learners' ability to apply self-regulatory processes. This is particularly true for students with learning disabilities, who ascribe their failures to low ability and their successes to external factors (such as easy assignment).

A link between metacognition and academic performance

The literature points to a positive association between metacognitive ability and academic achievements (Bransford et al., 1999; Chytrý et al., 2020; Thomas and Barksdale-Ladd, 2000; Veenman et al., 2006). Such as in relation to reading, metacognitive knowledge is known to allow learners to plan their actions, organize and evaluate information, choose suitable strategies, and improve their learning and memorizing processes. Additionally, metacognitive strategies are known to compensate for inadequate reading skills. Educators are thus encouraged to actively teach metacognitive strategies when they teach reading (Abdullateef and Ali, 2008; Martini and Shore, 2008; Perels et al., 2009). Similar findings are available for other school subjects (such as chemistry, science literacy, and psychomotor tasks) in which metacognitive abilities were predictors of academic success. Specifically, students who were encouraged to apply metacognitive skills (such as planning, supervision, evaluation, applying strategies before, during, and after a task) showed improved achievements in domain knowledge and in metacognitive awareness compared with the control group whose members had not received metacognitive instruction (Michalsky et al., 2009).

In mathematics, metacognitive skills like self-regulation and supervision of learning are necessary for students to solve mathematical problems as well as perform other intellectual tasks, such as reading and writing. Often, these skills are absent in weaker students of mathematics (Kramarski and Mizrachi, 2006; Villa and Sebastian, 2021).

Locus of control

The term locus of control refers to one's belief in the reasons for things happening to one, that is, one's perception of ability or inability to control the events in one's life. Locus of control is a spectrum. People with an external locus of control believe that external forces like destiny, luck or the level of difficulty determine the outcome: all outcomes are predestined and a person cannot change them. On the other end of the spectrum, people with an internal locus of control take responsibility for outcomes, have a sense of control and believe in their ability to influence situations (Abouserie, 1994; Boss and Taylor, 1989).Several researchers believe that locus of control can be inconsistent because it is situation- and domain-dependent. For example, people may consider themselves responsible for their own successes and failures in their workplace and at the same time ascribe their record at school to an external cause. Usually, people's behavior can be predicted by the orientation of their locus of control—external or internal—but under unusual circumstances they may deviate from their own, predictable, patterns (Olugbemiro et al., 1999). Locus of control begins developing in childhood, and is shaped by experience and learning. In time, one's position as being either in control of circumstances or subject to them becomes fixed (Mooney et al., 1991). Locus of control is shaped in a cognitive process of learning, in which one forms an expectation about the relationship between behavior and outcome. In other words, this is a learned pathway, which associates cause and result.

Locus of control can be understood as a sense of capability; however, this is only true in a very limited way, because locus of control describes one's self-evaluation in a specific situation, whereas a sense of capability applies more broadly. By taking the blame for failures and credit for successes (internal locus of control), or, conversely, disowning responsibility both for failure and success (external locus of control), one may avoid facing negative feelings, but at the same time satisfaction with achievements is also lost (Katz, 1994).

Overall, people with internal locus of control show more independence, competitiveness, industriousness, initiative, nonconformity, commitment, responsibility, as well as preemptive thinking, ability to find alternatives, creativity, will to control and change circumstances as necessary, and learning in order to improve future functioning. People whose locus of control is external tend to be conservative, anxious, and passive, take less personal responsibility, are more defensive, and have difficulty coping with their environment. People with internal locus of control are also better at adapting to their environment, because they believe in their ability to manipulate it. Conversely, people with external locus of control tend to fear difficulties and are slower to adapt (Mooney et al., 1991).

Association between locus of control and academic performance

Studies have found an association between locus of control and a number of behaviors that increase the probability of academic success and between locus of control and better academic achievements (Anderson, 1990; Villa and Sebastian, 2021). Schmitz and Perels (2011) highlight the differences in loci of control throughout the learning process. An internal locus of control entails data collection, because knowledge imparts a feeling of control and charts the route to a solution. Similarly, in the case of failure, causal thinking is needed to analyze the reasons for failure and to infer what should be changed. Over time, this sort of thinking builds up learning experience and better learning skills that rely on data collection and decision-making, and which are essential to improving achievements and becoming more effective. Perhaps 'internals' have more complex schemes of data collection, processing, and storage and this influences their efficacy. The learning schemes of 'externals' are not as well established or as well developed: when they experience success they are unable to reproduce it, and this is true also for learning and improving efficacy after a failure. 'Externals' do not need to work at collecting data or examining the reasons for success and failure. Their position is that the same external factors that influenced the present outcome will also affect any future action, whereas they themselves have no part in it.

Finger (2010) too found a positive association between internal locus of control and academic achievements: the more internal the locus of control, the better the academic achievements. She also found that people with an internal locus of control actively seek information—a necessary skill in academic performance—and use it better than those with external locus of control. People with an internal locus of control are distinctly self-motivated to learn and do not blame others for their own failures. Studies of students who managed their learning independently have shown that these students tended to choose suitable strategies for achieving their goals, and that they were able to solve problems that they encounter en route. These students were also highly motivated to learn and showed ability to address the learning tasks they set themselves. Independent learners believe that learning is a methodical and controllable process (Kaniel, 2006).

Learning disability and mathematics

The DSM-5 defines learning disability as a specific learning disorder (SLD) in three separate academic areas: (a) specific learning disorder with a reading disability; (b) specific learning disorder with a writing disability; (c) specific learning disorder with a mathematics disability (APA, 2013; Tannock, 2013). The DSM-5 recommends diagnosing learning disabilities based on lists of skills. Such as, a specific learning disorder with reading disability may manifest as inaccurate, slow, or labored reading of words: decoding words incorrectly, slowly, or hesitantly, guessing words, difficulty enunciating, or difficulty understanding the sequence, relationships, conclusions, or deeper meaning of a text. A specific learning disorder with a writing disability may manifest as illegible handwriting, effortful writing, difficulty in constructing paragraphs, and multiple spelling, syntax, and punctuation errors. A specific learning disorder with a mathematics disability is likely to manifest as difficulty understanding numbers, recalling facts, making calculations, applying concepts, facts, or arithmetic procedures when solving exercises (APA, 2013).

The definition learning disability as SLD was first introduced in the DSM-5, and demonstrates the emerging need for a classification method. The requirement for specificity reflects the progress made in both research of learning disabilities and in treating it, because the specific definition facilitates focused intervention (Tannock, 2013). Other features of the DSM-5 definition of this disability show that learning disabilities are of neurological-cognitive rather than environmental origin. Similarly, sensory and emotional disorders, and physical or intellectual disability do not count as a cause of SLD. The definition also includes the existence of a marked gap between IQ and academic achievements. A further distinction can be made, between developmental learning disability and academic learning disability: Developmental learning disabilities are usually discovered at pre-school age and include delayed acquisition of fundamental skills such as attention, memory, language, perception and motor abilities, and cognitive disorders. Academic learning disabilities include impaired skills that are usually acquired during early stages of learning in school: reading, writing, spelling, and mathematics (APA, 2013).

In Israel, the Ministry of Education is guided by two of the DSM-5 criteria: a marked and persistent gap between actual academic achievements and expected achievements by age and class; and a marked discrepancy between actual academic achievements and intellectual abilities as measured in objective IQ tests (Ministry of Education, 2009). Students with SLD are known to be deficient in metacognitive processing. In that they apply less metacognitive thinking when they solve problems than students without learning disabilities. This is in addition to deficiencies in planning, checking, and evaluating their work. Furthermore, Garrett et al. (2006) have shown that metacognitive difficulties are a strong predictor of learning disability. Although the effect of SLD is not limited to the academic sphere, its impact is most intensively felt during a student's years at school. Several studies point to mathematics being a school subject in which students with learning disabilities experience marked difficulties (Bishara, 2005). Consequently, some have SLDs that hamper their ability to learn mathematics. One example is a difficulty making abstractions, which can impair mathematical skills like ability to draw conclusions independently, generalize from one case to many, and apply a general rule to an individual case. Spatial orientation disability is another example. It may make it harder to distinguish sizes, understand spatial concepts, and decipher problems in geometry. Visual perception and audiovisual integration disabilities can make it hard for a learner to understand demonstrations and connect a model to an abstract schema. Similarly, a sequencing disability can affect functioning in arithmetic, decoding and writing numbers, remembering sequences of arithmetic operations (Montague, 2005).

Metacognitive knowledge, locus of control, and mathematical jokes in students with learning disabilities

The association between metacognitive knowledge, locus of control and use of mathematical jokes in the classroom has not been studied in populations of students with learning disabilities. Some studies show a link between metacognition and success in mathematics. The studies that examined the effect of direct instruction of metacognitive skills on achievements in mathematics have shown that exposure to a metacognitive approach and metacognitive practice fostered students' motivation and mathematical literacy (Kramarski and Mizrahi, 2006).

Kramarski et al. (1997) found that self-regulation practice based on asking questions independently improved the performance in mathematics of low-achieving third-graders and helped reduce their anxiety about mathematics. According to this study, training students in self-directed learning, using cognitive and metacognitive features, developed a strong sense of self-efficacy in students; they felt able to monitor their own thinking, solve word problems, and perform several types of transference. Perels et al. (2009) examined this association in an intervention study in which students were taught metacognition and self-regulation practices during mathematics classes. They found that students who received metacognitive instruction achieved better results in a post-intervention exam compared with a pre-intervention exam. Students who had not received the intervention did not show a similar improvement.

Many studies have shown that an internal locus of control and high self-esteem are related to better ability to cope with academic stress, persevere at tasks, and willingness to accept assistance and instruction at school (Abouserie, 1994; Maqsud, 1993; Mooney et al., 1991). Active learners are effective learners, but students with learning disabilities are characteristically passive learners, believers in external effectors, who display an acquired helplessness. Both their misguided beliefs and their passive approach impede their ability to learn and contributing to low self-efficacy, hopelessness, and lack of motivation (Margalit, 2003). Mokhtari and Reichard (2002) showed that poor readers or readers with learning disabilities knew less about their reading assignments, were less able to monitor their understanding as they read, and were less able to apply strategies to compensate for their reading comprehension difficulty. Even where the weaker readers knew such strategies, they did not apply them to solve problems. Metacognitive interventions for students with learning disabilities have been studied, and research has shown that direct instruction of metacognitive skills helped these students become independent learners. Furthermore, students with learning disabilities who received direct intervention in the form of metacognitive skills instruction improved their performance in mathematics (Fuchs et al., 2008).

In another study of locus of control, metacognition, and academic performance, 712 students who were selected by level of achievements responded to questionnaires about learning habits and preferences. In this study, the high-performance group showed a positive link between applying metacognitive processes and having an internal locus of control, and the low-performance group showed a negative link between applying metacognitive processes and having an external locus of control (Olugbemiro et al., 1999). Unlike the Olugbemiro study, which recruited college students, the present study tested middle school children with learning disabilities. Integrating jokes in class is considered an important aspect of social interaction even at young ages, and an aid to cognitive development: Using diverse forms of complex verbal formulations, including jokes, helps to develop cognitive abilities, increases metacognitive knowledge, and fosters an internal locus of control (Jackson et al., 2021; Tonkovich, 2020).

This is the core of the present study, which examined the links and the differences in metacognitive knowledge, locus of control, and understanding of mathematical jokes between students with and without learning disabilities. Considering the importance of mathematics and its related skills to students' futures, it is expedient to identify variables that can help students improve these skills, such as those studied in the present paper. This is particularly important for students with learning disabilities, who experience greater difficulty in mathematics and consequently achieve less.

Study hypotheses

1. There is an association between metacognitive knowledge in mathematics and locus of control, such that greater metacognitive knowledge in mathematics is associated with a more internal locus of control, and poorer metacognitive knowledge in mathematics is associated with a more external locus of control.
2. There is an association between metacognitive knowledge in mathematics and understanding of mathematical jokes, such that greater metacognitive knowledge is associated with better understanding of mathematical jokes, and poorer metacognitive knowledge is associated with poorer understanding of mathematical jokes.
3. There is an association between locus of control and understanding of mathematical jokes, such that a more internal locus of control is associated with better understanding of mathematical jokes, and a more external locus of control is associated with poorer understanding of mathematical jokes.
4. The two study groups will differ on level of metacognitive knowledge, locus of control, and understanding of mathematical jokes. Compared with students without learning disabilities, students with learning disabilities will show poorer metacognitive knowledge, less internal locus of control, more external locus of control, and poorer understanding of mathematical jokes.

METHOD

Participants

Participants in this study were 30 ninth-grade students with learning disabilities who attend integrated classes in general education schools and 30 ninth-grade students who attend general education schools, 37 boys (61.7%) and 23 girls (38.3%). The students with learning disabilities had undergone a psychological evaluation by the Counseling Services in their area irrespective of this study. This evaluation includes diagnosis by a psychologist of the type of disability and a WISC IQ test. It also includes a didactic assessment for reading, reading comprehension, mathematics, and English by qualified didactic evaluators using accepted instruments, and additional developmental evaluation of visual-motor, visual, hearing, language, memory, cognitive, and attention skills.

Research instruments

Data were collected using three instruments: a metacognition position questionnaire, a locus of control position questionnaire, and a position questionnaire regarding mathematical jokes.

Metacognitive position questionnaire

The questionnaire used was developed by Kramarski et al. (1997) to test students' general metacognitive knowledge used while solving mathematical problems. There are 29 statements in the questionnaire about general beliefs and strategies regarding solving mathematical problems. Respondents were asked to express their level of agreement with the statements on a Likert scale of 1 (strongly disagree) to 5 (strongly agree). For example, "First I look for the problem's mathematical structure." The questionnaire addresses the following types of strategies and metacognitive beliefs about solving mathematical problems. (a) pre-solution strategies (Items 1-6, 16), for example, "I imagine the story in the problem to myself"; (b) mid-solution strategies (Items 7–12, 20), for example, "I organize the data in a table"; (c) post-solution strategies

(Items 13–15, 17, 19), for example, “When I get an answer that doesn’t make sense I try to solve the problem in another way”; (d) beliefs about solving mathematical problems (Items 18, 21–29), for example, “There is one way to solve a mathematical problem.”

Scores were calculated by averaging the ranking of all the items. A higher score indicates increased use of a strategy or greater belief in the statement. Reliability of the instrument was tested in the present study and was α=.73. Reliability for pre-solution strategies was α=.86, for mid-solution strategies α=0.72, for post-solution strategies α=0.63, and for beliefs about solving mathematical problems α=.85.

Position questionnaire for locus of control (Katz, 1994)

This questionnaire was designed to test whether the respondent has a more internal or more external position. There are 24 statements in the questionnaire, of which 14 test for external locus of control (such as, “It is a matter of luck whether pleasant things to happen to me,”), and 10 test for internal locus of control (such as, “Usually, when someone is angry with me, I am able to do something about it”). Respondents are asked to express their level of agreement with the statements on a Likert scale of 1 (strongly disagree) to 5 (strongly agree). Reliability of the instrument was α=0.63. The scores for internal locus of control were calculated by averaging the item scores: a high score means internal locus of control and a low score means external locus of control. The scores for external locus of control were calculated by averaging the individual item scores: a high score means external locus of control and a low score means internal locus of control. Katz reports a high reliability coefficient, α=0.81 (Katz, 1994). In the present study, reliability of internal locus of control was α=.84 and reliability of external locus of control was α=0.91.

Understanding mathematical jokes questionnaire

The mathematical jokes questionnaire was developed by Gazit (2011) to test how well respondents understand the mathematical jokes in the questionnaire. There are eight jokes of varying levels of difficulty in the questionnaire, and respondents are asked to rank how well they understood the joke on a Likert scale of 1 (very little) to 5 (very well).

The scores were calculated by averaging the individual item scores: a high score means that jokes were well understood and a low score means the jokes were not understood. In the present study, reliability of the mathematical jokes questionnaire was α=0.88.

Research method

The questionnaires were submitted to ninth-grade students with and without learning disabilities at their schools, in coordination with the school staff. Participants responded to three questionnaires: a metacognitive knowledge questionnaire, a locus of control questionnaire, and a questionnaire to gauge understanding of mathematical jokes. Students were told that the questionnaires were anonymous, that there is no single correct answer, and that for each statement they are asked to select the answer that best reflects their position. Participants were asked to state their age, gender and class. Statements and jokes were read aloud to the students, who then marked their answers on their sheets.

Data processing

Averages and standard deviations were calculated for both research groups. Associations between the study variables were tested using Pearson correlations. Differences in metacognitive knowledge, locus of control, and grasp of mathematical jokes were tested using t-tests for independent samples. Data were processed using SPSS version 25.

FINDINGS

Descriptive statistics of the study’s variables were calculated in a preliminary analysis. Table 1 shows average metacognitive knowledge, locus of control, and grasp of mathematical jokes in the study populations and standard deviation. The averages in Table 1 show that cognitive knowledge for the entire sample was better than moderate (average range is 3.34–3.56) and also grasp of mathematical jokes was better than moderate (M=3.78, SD=.64). Based on skewness measures, the distribution was normal and approximately symmetric (skewness of −1–+1).

Association between metacognitive knowledge and locus of control

To test the first hypothesis, Pearson correlations were calculated for metacognitive knowledge and locus of control in the entire sample and in each of the two study groups (Table 2).

As hypothesized, the correlations shown in Table 2 indicate a significant positive correlation between metacognitive knowledge measures (except for post-solution, which was not significant) and internal locus of control in both groups and in the entire sample. In addition to this, as hypothesized, there was significant negative correlation between metacognitive knowledge measures (except for post-solution, which was not significant) and external locus of control in both groups and in the entire sample. This pattern of findings shows that greater metacognitive knowledge correlates with a more internal locus of control, and lower levels of metacognitive knowledge correlate with a more external locus of control. The patterns of association are similar in both groups on all measures.

Association between metacognitive knowledge and understanding of mathematical jokes

To test the second hypothesis, Pearson correlations were calculated between measures of metacognitive knowledge and grasp of mathematical jokes in each of the two study groups (Table 3).

Looking at the correlations shown in Table 3, as hypothesized, there was significant positive correlation between metacognitive knowledge measures (except for post-solution, which was not significant) and grasp of mathematical jokes in both groups and in the entire sample. This pattern of findings shows that higher levels

Table 1. Average and standard deviation for metacognitive knowledge, locus of control, and grasp of mathematical jokes in the study populations (N=60).

Variable	M	SD
Metacognitive knowledge measures		
Pre-solution	3.57	0.53
Mid-solution	3.83	0.60
Post-solution	3.66	0.64
Beliefs about solving mathematical problems	3.86	0.42
Locus of control measures		
Internal	3.56	0.60
External	3.34	0.81
Understanding mathematical jokes measures		
Understanding mathematical jokes	3.78	0.64

Score range was 0.5–1; a higher score indicates higher level of metacognitive knowledge, greater internal locus of control, and better grasp of mathematical jokes.

of metacognitive knowledge correlate with better understanding of mathematical jokes. The patterns of association are similar in both groups on all measures.

Association between locus of control and understanding of mathematical jokes

To test the third hypothesis, Pearson correlations were calculated between measures of locus of control and grasp of mathematical jokes in each of the two groups (Table 4).

Looking at the correlations shown in Table 4, as hypothesized, there was significant positive correlation between internal locus of control and grasp of mathematical jokes, and significant negative correlation between external locus of control and grasp of mathematical jokes in both groups and in the entire sample. This pattern of findings shows that more internal locus of control correlates with better understanding of mathematical jokes, and more external locus of control correlates with poorer understanding of mathematical jokes. The patterns of association are similar in both groups on all measures.

Differences in metacognitive knowledge, locus of control, and grasp of mathematical jokes by study group

To test the fourth hypothesis, t-tests for independent samples were calculated (Table 5).

Looking at the t-test values in Table 5, the students with learning disabilities showed significantly lower average metacognitive knowledge, internal locus of control, and grasp of mathematical jokes compared with students without learning disabilities. Conversely, their average external locus of control was significantly greater than in the students without learning disabilities. As hypothesized, students with learning disabilities scored lower on metacognitive knowledge measures and on internal locus of control, higher on external locus of control, and lower on understanding of mathematical jokes.

DISCUSSION

This study aimed to study the associations between metacognitive knowledge, locus of control and ability to grasp mathematical jokes used in mathematics classes in students with and without learning disabilities. To this end, possible associations were tested between the three variables: metacognitive knowledge, locus of control, and grasp of mathematical jokes, and differences noted between the two groups on the three variables.

Association between metacognitive knowledge and locus of control

The first hypothesis proposed that metacognitive knowledge in mathematics is associated with locus of control, such that greater metacognitive knowledge correlates with a more internal locus of control, and poorer metacognitive knowledge in mathematics correlates with a more external locus of control. The present study partly confirmed this hypothesis in both the research groups.

The present findings agree with earlier studies that,

Table 2. Pearson correlation between measures of metacognitive knowledge and locus of control for the entire sample and the two groups: with learning disabilities (N=30) and without learning disabilities (N=30).

Variable	With learning disabilities (N=30)		Without learning disabilities (N=30)		Entire sample (N=60)	
Metacognitive knowledge	Internal locus of control	External locus of control	Internal locus of control	External locus of control	Internal locus of control	External locus of control
Pre-solution	0.155	−0.30*	0.161	−0.35	0.158	−0.33**
Mid-solution	0.25*	−0.31*	0.29*	−0.37*	0.28*	−0.35**
Post-solution	0.35*	−0.20	−0.39*	−0.23	0.36**	−0.22
Beliefs about solving mathematical problems	0.52*	−0.61*	0.57*	0.67*	0.55**	−0.66**

*p<.05, **p<.01, ***p<.001.

Table 3. Pearson correlation between measures of metacognitive knowledge and grasp of mathematical jokes in the two groups: with learning disabilities (N=30) and without learning disabilities (N=30).

Measures of metacognitive knowledge	Mathematical jokes		
	With learning disabilities (N=30)	Without learning disabilities (N=30)	Entire sample (N=60)
Pre-solution	0.50*	0.52**	0.50**
Mid-solution	0.36*	0.40*	0.39**
Post-solution	0.21	0.25	0.23
Beliefs about solving mathematical problems	0.61*	0.64*	0.63**

*p<.05, **p<.01, ***p<.001.

Table 4. Pearson correlation between measures of locus of control and grasp of mathematical jokes in the two groups: with learning disabilities (N=30) and without learning disabilities (N=30).

Locus of control	Mathematical jokes		
	With learning disabilities (N=30)	Without learning disabilities (N=30)	Entire sample (N=60)
Internal	0.60*	0.64*	0.62**
External	−0.79*	−0.83**	−0.81**

*p<.05, **p<.01, ***p<.001.

showed an association between metacognitive knowledge and locus of control. As noted in the review the literature proposes that students' metacognitive knowledge and the strategies they choose can explain the link between locus of control and academic performance. Indeed,

Table 5. Average, standard deviation, and t-test values for measures of metacognitive knowledge, locus of control, and grasp of mathematical jokes in the two groups: with learning disabilities (N=30) and without learning disabilities (N=30).

Variable	**Students with learning disabilities (N=30)**		**Student without learning disabilities (N=30)**		**t(58)**
Measures of metacognitive knowledge	**M**	**SD**	**M**	**SD**	
Pre-solution	3.51	0.33	3.63	0.24	4.23**
Mid-solution	3.79	0.34	3.87	0.30	5.26**
Post-solution	3.61	0.41	3.69	0.21	4.86**
Beliefs about solving mathematical problems	3.81	0.44	3.91	0.19	6.12**
Locus of control measures					
Internal	3.52	0.45	3.60	0.22	9.28**
External	3.40	0.51	3.28	0.17	18.82**
Mathematical jokes					
Understanding mathematical jokes	3.65	0.96	3.91	0.98	14.83**

*p<0.05, **p<0.01, ***p<0.001
Score range was 0.5–1; a higher score indicates higher level of metacognitive knowledge, greater locus of control, and better grasp of mathematical jokes.

learners with internal locus of control present better achievements and better academic performance (Mooney et al., 1991). Furthermore, Arslan and Akin (2019) argue that the two key motivational factors associated with academic success are metacognition and locus of control. Both metacognition and locus of control are related to perceptions of self that can function as internal resources created about oneself and one's interaction with the surroundings. It seems, therefore, that metacognition and locus of control are key characteristics of academic success. This is compatible with the present study's findings, which show that internal locus of control is a positive predictor of metacognitive knowledge and internal locus of control is a negative predictor. Thus, the present findings regarding the link between better metacognitive knowledge and a more internal locus of control support existing literature.

Association between metacognitive knowledge and understanding of mathematical jokes

The results of the present study confirmed the second hypothesis regarding a link between metacognitive knowledge and ability to grasp mathematical jokes in both groups of participants: greater metacognitive knowledge was associated with better understanding of mathematical jokes and poorer metacognitive knowledge was associated with poorer understanding of mathematical jokes.

This is in line with Jackson et al. (2021) who claim that incorporating jokes in teaching helps students' cognitive development. Reilly (2006) argues that humor as a communicative process in the context of learning can spark creativity and expand the range of possibilities that students entertain. In this way, humor plays a role in promoting advanced cognitive and metacognitive skills, which is particularly meaningful when contending with a complex learning task like mathematics.

Association between locus of control and understanding of mathematical jokes

The present study confirmed the third hypothesis in both research groups regarding an association between locus of control and understanding of mathematical jokes—internal locus of control with greater understanding and external locus of control with poorer understanding. These findings support reports in the literature regarding such an association. Such as, a study of college students showed that students with internal locus of control expressed more joy, and smiled more when they heard and understood humor during classes than students with external locus of control. There was a similar difference between the two groups in their academic achievements, level of stress, and normal social interactions—students with internal locus of control did better at their studies, were less stressed, and were better at forming social interactions (Lefcourt et al., 1983).

Interestingly, the first three sets of findings presented here and their implications apply to students both with learning disabilities and without learning disabilities. Existing research shows that teaching metacognitive skills helped students with learning disabilities become independent learners, and that their performance in mathematics improved (Fuchs et al., 2008). In this respect, the present findings suggest a novel point, as the association between metacognitive knowledge, locus of control, and mathematical jokes in the classroom has not been studied before in populations of school children with learning disabilities.

Differences in metacognitive knowledge, locus of control, and grasp of mathematical jokes by study group

As proposed by the fourth hypothesis, the findings of this study showed that students with learning disabilities did worse on measures of metacognitive knowledge and internal locus of control, had greater external locus of control, and their understanding of mathematical jokes was poorer. One insight about students with learning disabilities becomes clear in light of existing research presented so far. Students with learning disabilities often present poorer metacognitive processes—processes with both motivational and emotional elements. This is important because emotions have been found to be significant predictors of self-directed learning and of achievements (Ahmed et al., 2013; Mega et al., 2014). Students with SLD are known to be deficient in metacognitive processing. Thus, students with learning disabilities apply less metacognitive thinking when they solve problems than students without learning disabilities. This is in addition to deficiencies in planning, checking, and evaluating their work.

Students with learning disabilities have a further deficiency related to their poorer metacognitive knowledge, that is due to the way metacognitive knowledge and metacognitive strategies are used to compensate for deficient skills. Often, students with a learning disability are at a disadvantage in class compared with students without learning disabilities who are able to rely on metacognitive knowledge to compensate for deficiencies. This would create a double deficiency in the already deficient students with SLD and increase the gap in achievement between and them non-SLD students. Metacognitive skills are of particular importance in mathematics and indeed are deficient in students who have difficulty in mathematics (Kramarski et al. 1997).

This allows us to describe a process in which the learning disability, which is associated with poorer metacognitive processes, unites with the learner's use of external locus of control to interpret difficulties and failures, to reaffirm the learner's often-reduced self-perception of ability in mathematics. This connects with external locus of control and these students' belief that their success in mathematics is out of their hands. It is possible that students with learning disabilities who are having trouble with mathematics form a stable locus of control that is more external than internal based on their past experiences, which led them to conclude that they are controlled by circumstances they cannot help. As described in the review, locus of control is a cognitive learning process with a generalized expectation of an association between behavior and outcome, or cause and effect. This is explained by people's tendency to seek a causal relationship between their behavior and its outcomes, and create expectations of future outcomes by generalizing from past events. This expectation built by generalizing from a specific case to purportedly similar situations eventually becomes a personality variable, which affects behavior in specific cases (Finger, 2010).

Finally, as shown for the second hypothesis, incorporating jokes in instruction can help students' cognitive development. As this study examined correlations, it is possible to look at the equation in reverse: Poorer ability to understand mathematical jokes is associated with poorer cognitive knowledge and more external locus of control, as this study has shown.

CONCLUSIONS AND PEDAGOGICAL IMPLICATIONS

This study contributes to existing theoretical knowledge about the structural links between level of metacognitive knowledge, locus of control, and incorporating mathematical jokes in the instruction of students with learning disabilities compared with students without learning disabilities. This should expand scientific dialog and research in the area of metacognitive knowledge and locus of control in both populations. In practice, this study provides some basis for encouraging teachers, students, and education professionals to use metacognitive knowledge and internal locus of control tools to help students with learning disabilities learn. By focusing on metacognitive knowledge and internal locus of control training, intervention programs developed specifically for students with learning disabilities can help these students improve their mathematics and other school subject achievements.

Counselors in schools can promote appropriate intervention policies for students with learning disabilities and advise educational system officials regarding ways of implementing these policies. This would require long-term and closer collaboration between school counselors and the educational system.

STUDY LIMITATIONS AND SUGGESTED FUTURE RESEARCH

As in many studies of this type, this study has a number of limitations. It would be interesting to explore how the variables tested in this study (metacognitive knowledge, locus of control, understanding mathematical jokes) are associated with other variables such as executive function, self-efficacy, and self-image. The present study focused on students only, and did not address other educational system factors, such as: teachers and superintendents, local authority officials, and parents to find out whether any of them affect metacognitive knowledge, orientation of locus of control, and grasp of mathematical jokes.

Finally, this study principally applied quantitative methods. Future research should incorporate qualitative methods like interviews with students and teachers. This would provide a broader perspective and validate the present study's findings regarding the link between metacognitive knowledge, locus of control, and understanding mathematical jokes in class. It is also advisable to design intervention programs specifically for raising motivation and achievements in students with learning disabilities by developing metacognitive knowledge and more internal locus of control, and using mathematical jokes when teaching mathematics.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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