Brain Literacy Empowers Educators to Meet Diverse Learner Needs

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Abstract

The potential of educational neuroscience in teacher training and continuing professional development has been debated extensively, yet knowledge translation is largely absent in this field. Without objective methods for translating and disseminating educational neuroscience evidence, the impact of training on educators and the children they serve will remain limited. This position paper addresses this critical teacher education need by providing a rationale for why brain literacy training is vital as teachers learn to meet the needs of diverse learners. The authors offer three important factors for consideration regarding the utility of educational neuroscience for educators and allied school practitioners. First, the foundations and history of professional educator development in educational neuroscience will be considered. Second, a brief review of the empirical learning science literature within the context of science-based education will be considered. Third, a rationale for including a more intensive brain literacy training for educators is provided by comparing the impact traditional teaching practices and brain literate strategies have on curriculum and instruction, and how standard practices may actually undermine student brain development. Finally, three recommendations for developing educator brain literacy are offered to guide future policy, research, and practice decisions.

Keywords: Diversity, Neuroscience, Disability, Education, Training

Introduction: Meeting Learner Needs in Diverse Classrooms

An ongoing challenge for educators and policymakers is determining how best to meet the complex cognitive, academic, behavioural, and psychosocial needs of children in our pluralistic world. In these turbulent political and cultural times, many educators value and are trying to accommodate social, cultural, racial, gender, and linguistic differences among children. However, cognitive diversity is seldom considered, in part because educators are not trained to recognize student cognitive differences, or how these differences might impact their instruction or student academic success. Thus, while most educators recognize and value cognitive diversity in the abstract, they are ill-prepared to understand individual learning differences in the classroom, and how to adjust their instruction to meet individual learning needs, and they are less likely to have positive attitudes toward inclusive education for children with disabilities (Vaz et al. 2015).

Recognizing learner differences remains a critical skill that teachers must develop while understanding that academic failure has considerable individual, social, and economic consequences. Every day, teachers see students excel in some areas and struggle in others. Some students grasp classroom instruction and obtain curricular objectives with relative ease, while others may have difficulty with initial learning, or recalling previously learned material. Not only must teachers recognize individual learner differences, they need the skills and materials necessary to provide alternative instructional strategies to meet wide-ranging student needs. However, without training in cognitive diversity, a teacher's approach may be less than optimal for the diverse learners in his/her classroom.

Although there are many overlapping concepts between education and psychology, and psychology and neuroscience, what is needed is cross-fertilization of knowledge and skills across all three disciplines. It is important to recognize that psychological and neural explanations of behaviour should be seen as complementary, rather than competitive, with each other (Howard-Jones et al., 2016). Brain literacy, like all literacy, requires exposure, explicit instruction, knowledge translation, practice, and continuing education. Developing brain literacy is helping educators realize how diverse thoughts and behaviours are governed by the brain, not only among their students, but also by their own brain functioning.

Misinformation about the relevance of neuroscience for education abounds, with some claiming there is no evidence that neuroscience has led to new and effective teaching methods (Bowers, 2016). This neuroscience-education divide occurs because there are few neuroscience laboratory researchers who have the in-depth knowledge of classroom curriculum and instruction (Willingham, 2009; Worden, Hinton, & Fischer, 2011). This knowledge is critical for translating research findings into meaningful classroom-based practice for educators. The problem with neuroscientists not knowing enough about classroom instruction is one factor. It is compounded by the fact that very few educators and policymakers realize that classroom instruction can develop student cognitive and psychosocial brain functioning (Hale, Chen, Tan, Poon, Fitzer, & Boyd, 2016). This is in part due to the absence of formal educator training or supervised experience in applying knowledge of brain-behaviour relationships in classrooms (Fischer, 2008; Goswami, 2006; Pickering & Howard-Jones, 2007). Developing formal training programmes for teachers to help them understand the latest developments in neuroscience and how they apply to education will only help make educational systems stronger, allowing teachers to recognize how individual learner differences intersect with curricular goals and objectives, ensuring our diverse student body is optimally prepared for success.

Educational Neuroscience

The ideas of brain-based learning have been periodically considered for many decades, so the informed reader must ask a critical question: What has changed over this period, and have changes been sufficient to consider incorporating brain literacy instruction in educator training today? The answer is in part related to tremendous advances in technology, which allow scientists to investigate brain structures and functions like never before. There are now literally millions of articles written that explain how the brain grows, thinks, learns, and behaves, and what happens when neurodevelopment goes awry. For example, there have been 1.73 million active researchers in the area of brain and neuroscience research since 1996 and approximately 1.79 million articles on brain and neuroscience research were published between 2009 and 2013 (Elsevier, 2014). More functional Magnetic Resonance Imaging (fMRI) studies conducted on human participants were published between 2009 and 2012 than in the 17 years prior (1992–2009); (Stelzer, Lohmann, Mueller, Buschmann, & Turner, 2014). This explosion of literature has re-written long-held assumptions about brain-behaviour relationships and their impact on classroom achievement and behaviour (Fischer, Goswami, & Geake, 2010; Meltzoff, Kuhl, Movellan, & Sejnowski, 2009).

Although scientific discovery leads to new theories and furthers research efforts, scientific discoveries can also potentially be relevant for changes in pedagogical practices that impact the lives of children in classrooms. Of the revolutionary advances in our understanding of brain and behaviour, three fundamental findings provide the impetus for embracing a brain-based approach to education:

- Like other areas where diversity is observed (e.g., gender, cultural, linguistic), cognitive diversity is the *norm* for a vast majority of children, not just children with special needs (e.g., Hale, Fiorello, Kavanagh, Holdnack, & Aloe, 2007);
- The brain is much more malleable than was anticipated and is constantly changing in response to environmental demands, suggesting learning and behavioural challenges can be overcome through systematic evidence-based instruction (e.g., Dubinsky, Roehrig, & Varma, 2013);
- Tailoring instruction based on an understanding of cognitive diversity not only maximizes student learning and behaviour, but it has also shown the potential to mitigate learning or behavioral difficulties from becoming a lifelong disability that is highly resistant to intervention (Koziol, Budding, & Hale, 2013).

Emerging evidence suggests understanding brain-based learning differences may be more advantageous than considering traditional behavioural outcome measures alone when designing instruction and tailoring intervention efforts (Gabrieli, Ghosh, & Witfield-Gabrieli, 2015; Hoeft et al., 2007), especially for our most vulnerable students (Gabrieli, 2016). This strongly suggests that there is real potential value in exploring brain-based approaches to assessment, instruction, and intervention. Despite the apparent face validity of the approach, a contentious and at times acrimonious debate has emerged as to whether those charged with educating children would benefit from a brain-based approach to curriculum and instruction, with misinformation and boundaries seemingly difficult to bridge or overcome (Beauchamp & Beauchamp, 2013; Hirsh-Pasek & Bruer, 2007). The main barrier of brain-based education is the research-practice divide acknowledged by advocates and opponents alike (Ansari & Coch, 2006; Carandini, 2012; Mason, 2009). The divide between neuroscience and school-based practice remains formidable.

While the “debate” about the need to teach educators brain literacy is ubiquitous in the literature, what is absent is research on what works and what does not in trying to bridge the gap. Without evidence to guide policymakers, investment in brain-based education approaches is left to individual educators who often seek training on their own. Although some brain-based education programs exist in the popular literature, most consist of single or multiple workshops often provided by those with limited neuroscience or neuropsychology training. As a result, misconceptions (often referred to as *neuromyths*) can be adopted, which in turn hamper translation efforts (Dekker, Lee, Howard-Jones, & Jolles, 2012). Practitioners have good intentions in seeking this knowledge, but information may be inaccurate, and can lead to teacher-initiated interventions that run counter to what we know is solid evidence-based practice. As is the case with other scientific advances, we need basic educational neuroscience research that is followed by clinical trials in the field to see what works (Roediger, 2013) and for whom (Gabrielli, 2016).

The Science of Learning and John Hattie's Contribution

Education has often had a vexed relationship with science, with some suggesting the lack of brain-based practice in the classroom and the prevalence of neuromyths is due to the differing goals, values, and methods of science and education (Palghat, Horvath, & Lodge, 2017). Willingham (2009) notes that the purpose of neuroscience is discovering and explaining brain-behaviour relationships, whereas the purpose of educational research is to develop pedagogical strategies that improve student outcomes in instructional environments. In addition, neuroscientist suggestions for educators are often based on results from laboratory settings, and do not take into account the more typical scenario of providing education to large groups of diverse learners. This difference in laboratory versus classroom settings can be seen as an impediment for translational brain literacy. Nonetheless, there is one area of education – the science of learning – which can potentially serve to bridge the science-practice gap. The science of learning draws from many different fields of study and on many different methods and techniques to better understand how learning happens— with the ultimate goal of maximizing learning for all (Gagnier, Fisher, & Landau, 2017). It is possible that the science of brain and the science of learning could be integrated into an optimal empirically-based practice that incorporates the best of both knowledge bases.

Probably the most influential of proponents of the science of learning is John Hattie, who has made tremendous strides in bringing science to classroom instruction. Hattie (2009) reviewed over 800 meta-analyses that involved over 50,000 studies and synthesized a report to better understand what works for student achievement based on empirical evidence. His synthesis addressed many important variables such as student, home, teacher, teaching strategies, and curricula. Throughout his book, *Visible Learning,* he suggested empirically-derived inferences about teaching, learning and environmental factors creating real and meaningful impact on student classroom performance. One key take-away message is that schools, particularly teachers and their teaching strategies, can make a direct impact on student achievement outcomes with the instructional methods they adopt. Specifically, it is critical to make instructional and learning success indicators visible to the teachers and students, and the importance of observable feedback and data collection is thus highlighted.

The learning science evidence-base, cognitive science, and educational neuroscience research findings seem to converge attesting to the validity of their relationship. This evidence suggests that the foundation for brain-based learning in schools has been laid but not capitalized on to date, at least not by prominent stakeholders who shape educational policies and practices. Perhaps the larger question is how to facilitate buy-in among stakeholders so that the critical infrastructure necessary for knowledge translation can be built, ensuring that newly developed educational neuroscience knowledge and skills can become meaningful for classroom-based practice.

The Potential Impact of Brain Literacy on Curriculum, Instruction, and Student Outcomes

One of the goals of developing teacher brain literacy is not only to sensitize teachers to student learner diversity, but also to see how newfound knowledge and skills relate to the curriculum teachers are required to teach, the instructional materials they use, their pedagogical style, and classroom delivery. To explore this complex interaction of curriculum, instruction, and outcome, brain literate teachers learn to re-evaluate commonly held beliefs and practices to consider more nuanced approaches in which their knowledge of neurodevelopment and brain structure and function can impact their actions and student behaviours. Not only can this improve academic outcomes and student behaviours, but it can also create a more effective and positive learning experience for all.

When “How People Learn: Bridging Research and Practice” was first published by the Committee on Developments in the Science of Learning following a two-year study commissioned by the National Research Council in the United States, the blueprint for brain-based education was put forward. This publication and the expanded volume published in Bransford et al., 2000, documented some of the key research findings about learning that could inform classroom practices about effective teaching. The key findings, consistent with the cognitive neuroscience and science of learning perspectives, suggested:

- Prior student knowledge and experience play a critical role in learning, affecting integration of new information and concepts;
- Developing student competency requires not only a foundation of factual knowledge, but also a conceptual framework to organize, retrieve, and apply the knowledge; and
- Students who develop metacognitive skills take control of their learning for developing learning goals, monitoring progress, and evaluating outcomes.

Bransford et al. (2000) defines experts as those who think effectively about problems in their specific areas and notes that learning experts are more likely to approach problem solving with principles, core concepts and big ideas than novices. Armed with a rich repertoire of knowledge, experts also organize their knowledge such that it is “conditionalised” to be retrieved and applied efficiently and fluently. Experts also have strong metacognitive skills, being flexible in adapting their knowledge for new problems and situations as well as transferring their knowledge to everyday environments. These skills would be particularly difficult for someone with executive or fluid reasoning difficulties, so strategies to improve planning, organizing, monitoring, evaluating and changing thinking and/or behaviour could be undertaken by the brain literate teacher. One of the common findings for children with executive dysfunction is inconsistent behaviour, so the brain literate teacher can work to understand this pattern of learning and behaviour, and tailor instruction to individual executive function needs.

The brain-based model (Hale, Wilcox, & Reddy, 2016) presented in Figure 1 forms the template for educators’ understanding of all brain behaviour relationships in the classroom during brain literacy training. Adopted as the contemporary model representing brain functioning by the American Psychological Association (Hale, Wilcox, et al., 2016), neuroscience evidence has revealed that most of the learning and behavioural difficulties experienced by children are not easily observed, so they are not “visible” like Hattie’s 2009 recommended instructional approaches. While educators can observe the behaviour or learning output, they cannot always see the neurological underpinning.

Insert Figure 1 Here

Instead of being visible (i.e., visual, auditory, tactile, kinaesthetic), most brain functions relevant for educators happen in what A. R. Luria termed the multimodal convergence “zones of overlapping” (back of the brain) or the executive “superstructure” (front of brain) (Schneider et al., 2013). Hale et al.’s model recognizes that these structures work as systems that interact with each other, so teacher and allied practitioner interpretation occurs along a gradient (Goldberg, 2002) or continuum of cognitive strengths and weaknesses. Even though these are visualized as dichotomies, all model axes have a continuum. Perhaps the most important bridge that needs to be made is between the invisible learning processes that must be inferred based on behaviour, and the visual learning strategies recommended by the science of learning. These behaviours are often the ones that most impact how teachers both treat and teach diverse learners.

Since brain functioning must be inferred by the brain literate teacher, training requires both knowledge acquisition and practice for competency. A strategy for helping educators better understand these brain differences is to have them consider real world examples through quality brain literacy instruction. In addition to knowledge acquisition through lecture and discussion, activities such as case studies of children from the teachers' classes, or interpreting an everyday behaviour from a neuropsychological orientation, are valuable activities designed to help educators translate knowledge into most effective practice. Not only does this provide important, real world examples to bridge the knowledge-practice gap, it also provides an important impetus for motivating teachers to enhance instructional efforts in the real world. The end-product is advanced teacher skill in addition to improved academic and behavioural outcomes for students. This training would also be enhanced by videotaping teacher lectures, or providing direct observation in the classroom, with debriefing focused on the teacher-student interactions during instruction.

Research on Teaching Brain Literacy

Providing brain literacy instruction to educators can allow them to better design curriculum, teach content, and manage behaviour (Hale, Wilcox, et al., 2016). Research conducted in North America has consistently shown teachers value training in educational neuroscience (see Hale, Wilcox, & Reddy, 2016), and this training helps reduce (but does not eliminate) educator neuromyths (Macdonald, Germine, Anderson, Christodoulou, & McGrath, 2017). In Singapore, participants from both mainstream and special schools significantly improved their knowledge, skills, and opinions after brain literacy courses. Both post-lecture and post-case presentation ratings were significantly higher than pre-course ratings for the Knowledge, Skills, and Opinions domains (Walker, Chen, Poon, & Hale, 2017).

However, the nascent state of the field dictates that further research is necessary to determine the optimal format for developing educator brain literacy knowledge and increasing the skills that impact both teacher competency and student learning outcomes. For brain literacy to be effective in enhancing teacher competency, researchers must study how training impacts classroom instruction and student outcomes. To this extent, it is not satisfactory to simply provide educator knowledge in traditional workshops or short courses; efforts must be undertaken to ensure it changes educator skills as well. If teacher skills are positively impacted, research is needed to see if brain literacy improves student academic and social outcomes.

It is important to note there are differences between traditional, standard teacher training and the type of brain literate training advocated in this discussion. To highlight the differences, Tables 1 through 3 are examples for three different areas of educational planning and delivery. These examples are not exhaustive and are not prioritized in any order, but are instead illustrative of potential differences between what is often taught in standard teacher education programs and what is taught by teachers trained in educational neuroscience and brain literacy.

Table 1 highlights the work that can be done at the curriculum level, which not only includes curriculum scope and sequence efforts developed by policymakers, but also addresses materials used to cover the curriculum such as textbooks, worksheets, and assignments. Prior work with the Alberta Ministry of Education curriculum specialists fostered a restructuring of curricular goals and objectives across multiple domains, thereby shaping curriculum, instruction, and assessment for hundreds of schools (Backenson, Hale, Kubas, Fitzer, & Carmichael 2013). The brain literate curriculum specialist is cognizant of how neurodevelopment influences learning and instruction while ensuring the necessary prerequisites for more advanced objectives are achieved in a logical, sequential, and progressive fashion that leads to the ultimate curricular goals (Geake & Cooper, 2003).

Not only should books, materials, media, and assignments match the curriculum sequence in a prescribed fashion, but the brain literate educator should also be aware of potential issues with how materials are constructed that may lead to student interference with mastering the curriculum objectives. Construct contamination and measurement issues within the context of neurodevelopment and cognitive diversity, such as how executive functions impact classroom performance, are important factors that need to be addressed when planning brain literacy curriculum development (e.g., Meltzer, 2011). Working with curriculum and measurement leaders simultaneously can ensure more reliable and valid high-stakes measures for better system evaluation and improvement.

Insert Table 1 Here

Table 2 represents common issues teachers face in the classroom with regard to academic achievement. Although these examples may or may not apply to certain educational systems, schools, classrooms, or teachers, they are nonetheless common examples of instructional practices used by teachers trained in traditional educational training programs and those who receive more advanced brain literacy instruction. The question often asked is one of teacher competence, and if expert teachers need brain literacy instruction to develop more advanced skills in order to detect individual differences and meet the needs of diverse learners (e.g., Fischer, Goswami, & Geake, 2010). In many cases, the answer would be yes – expert teachers may develop a more nuanced and sophisticated approach to understanding and serving all children, but the probability of this is enhanced by understanding how brain functions affect learning (Willis, 2010). The “value added” is that brain literate teachers develop these skills much more quickly than they would through trial and error experiences, effectively serving as expert teachers of children earlier in their careers.

In addition to brain literacy helping develop teacher expertise sooner, some of these symptoms or characteristics exhibited by students are not easily recognized without brain literacy, such as the importance of handwritten spelling in improving sound-symbol association when reading words (Berninger et al., 2006). To further elucidate this example, Berninger and colleagues have shown that spelling by hand (not typing or recognizing spelling accuracy) improves sound-symbol association, and neuroscience shows us the reason – the part of the brain that perceives (input) and maps sounds (phonemes) onto symbols (graphemes) is also well-connected to the area of the brain that writes (output) those symbols. In fact, the anterior frontal area associated with motor memory of letters, connects both directly and indirectly with the posterior parietal region which connects sounds with letters (Hale & Fiorello, 2004).

Another example that highlights this connection can be seen in the classroom. Children who have difficulty with sound-symbol association often move their lips when reading silently, suggesting the brain is trying to use this expressive language action to facilitate phoneme-grapheme perception (He et al., 2003; Heilman, Voeller, & Alexander, 1996), and that when children improve their connections of sounds with letters the lip movement disappears. These are examples that might not readily be recognized by even expert teachers with many years in the field. These teachers may have stumbled upon it by using a “multi-sensory” approach to teaching reading and spelling, but there is also the chance they missed it all together or did not understand what they were seeing in the child. Worse yet, they may recommend a student avoid spelling or handwriting, offering a keyboard and spell check instead.

Insert Table 2 Here

Table 3 highlights the differences between traditional instructional and brain literate practices for coping with behavioural issues often observed in the classroom. Teachers are often well-versed in instructional practices related to academic domains, but often report limited preservice training in behaviour management (Giallo & Little, 2003). Not only is effective behaviour management critical for ensuring maximum time and energy spent on learning, but it is perhaps even more importantly related to teacher satisfaction (Clunies-Ross, Little, & Kienhuis, 2008). Managing behaviour effectively is especially important to consider when teacher burnout is often caused by difficulties with classroom management of student disruptive or emotional behaviour problems (Egyed & Short, 2006).

Although certain examples of brain-behaviour instructional differences for brain literate teachers seem straightforward, it is common for teachers to misunderstand the basic tenets of behaviour or to manage similar behaviours (e.g., attention problems) with different causes in similar ways. Although not all examples in Table 3 occur in every classroom in every school, the consequences have been observed. There are protocols in place for student "discipline" problems in schools, but what we often find is that teachers and schools are actually requiring obedience to avoid punishment, instead of developing student self-discipline and self-control skills. While obedience can require self-control, it is often a result of obeying external factors. Self-discipline comes from understanding ourselves. Teachers and schools can help students develop better self-discipline through an understanding of student brain-behaviour relationships in the classroom.

Insert Table 3 Here

Recommendations for Developing Educator Brain Literacy

Ongoing and continual brain literacy instruction will be very beneficial for educators if neuroscientists work with educators in a bidirectional, reciprocal, cooperative, and transdisciplinary manner (Ansari, Coch, & DeSmedt., 2011; Beauchamp & Beauchamp, 2013; Edelenbosch, Kupper, Krabbendam, & Broerse, 2015), using neuroscience to optimize educational practices (Churches, Dommett, & Devonshire, 2017; Colvin, 2016; Roediger, 2013). The gap between neuroscientists, who know about the brain and learning but struggle to translate it into classroom practice, and educators, who advocate brain-based learning, but do not have a good understanding of it, remains formidable (Decker, Hale, & Flanagan, 2013; Gabrielli, 2016; Hale, Wilcox, et al., 2016; Palghat, Horvath, & Lodge, 2017; Reddy, Weissman, & Hale, 2013). The effort required to provide quality brain-based instruction will require substantial expertise and commitment from governments and teacher training institutions, and a collection of professionals engaged in translation of educational neuroscience into classroom-based practice. The suggestions below may provide a starting point for researchers and teachers to begin bridging the gap so that brain literacy impacts proper practice in the classroom.

Continued Efforts to Translate Educational Neuroscience into Accessible Language.

Recent research by Tham, Walker, Tan, Low, and Chen (2019; see this issue)) indicates that teachers want to learn more about neuroscience but need it presented in practical, implementable strategies that can help them immediately. A neuroscience educational clearinghouse) has been developed at the National Institute of Education in Singapore. The clearinghouse collates leading articles on neuroscience and translates the abstracts so they are more easily understood by practicing teachers. In addition, at least one practical example is provided per entry that explains how the research potentially impacts classroom practice and student performance. These types of resources are invaluable to teachers; however, they may not be enough. Academic researchers can also consider how their research can be reported in ways that are digestible to teachers in the field. Practitioners clearly want to understand how research can impact their work but they also want it to be reported in a way they can understand (Tham et al., this issue).

Continued Research on Brain Literacy Training Impact.

Research completed on brain literacy instruction demonstrates improved educator brain literacy knowledge, skills, and opinions regarding serving children with and without special needs in mainstream classrooms (Walker, Chen, Poon, & Hale, 2017; Tham et al., this issue). However, the qualitative reports produced and study results suggest the training could be enhanced by using a different format (more sessions, but briefer) or using a blended learning approach (e.g., webcast for content, small group exercises for applied component, direct observation and consultation in classrooms). These results would be taken into account when designing the courses and modules noted above. Most importantly, there is a critical need for research that examines teacher performance with students after the courses are completed. It is not enough to say the instruction is valued or helpful—it must change teacher skills and improve student outcomes. To accomplish this end, researchers, academics, practitioners, and policymakers must realize the inevitable conclusion that teaching is a process that changes student brain function (Hale et al, 2016), but educators need direct instruction in translating brain science to instructional practice.

Establishment of More Brain Literacy Courses in Teacher Education.

One possible way to help future educators understand and implement brain literacy will be for more teacher preparation programs to include an entire module focused on the brain and learning in teacher training programmes. Properly designed brain literacy courses are well poised to meet the call for bringing neuroscience to the classroom (Goswami, 2006). Not only can these courses improve teacher expertise and professionalism in brain-based differentiated instruction, but they should also improve student achievement and behaviour. Topics covered may include, but would not be limited to, numeracy, literacy, oral and written expression, working memory, attention control, emotional and/or behavioural self-regulation, instructional modifications and accommodations, and innovative neuroscientific technologies.

Conclusion

With combined efforts from a varied body of stakeholders, creative and effective methods to bring higher levels of brain literacy to educators is possible and necessary. Since educators are in charge of developing student skills that lead to changes in brain functioning, it is important for them to know how their instruction can be adjusted to address individual learner differences. The development of innovative training programs merging the fields of neuroscience and education will equip educators with powerful pedagogical tools to reach *all* learners. By empowering teachers with robust knowledge and skills in educational neuroscience, diverse student bodies can be better served through teaching practices designed to expand and grow their unique minds. While competency in teacher brain literacy will not happen immediately, the suggestions above are meant to provide the foundation for creating a more brain literate teaching force that works together with researchers in neuroscience to provide evidence-based practices in the classroom.

Disclosure statement

No potential conflict of interest was reported by the authors.

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