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Online Assessment of Students' Inductive Reasoning Skills Abilities in Oshana Region, Namibia

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ABSTRACT In recent years, a large number of studies have highlighted the importance and benefits of technology-based assessment. The goals of this study were (1) to examine the feasibility and reliability of technology-based assessment in Namibia; and (2) to assess students' abilities and the development of their inductive reasoning skills, comparing it with data from a small Chinese sample (N=50; 27 boys; 23 girls) using the same instrument as an indicative benchmark. The data collection was conducted in Oshana region, Namibia (N=621; 268 boys; 348 girls). Both the Namibian and the Chinese participants' average age was 12 years. The Rasch model was used for scaling the data and analysis. The reliabilities of the test proved to be high (Cronbach's α: .846). Namibian students performed significantly lower (M=-1.38, SD=.84) in the test compared to the benchmark sample (M=2.17, SD=.83). The results also suggest that technology-based assessment is feasible and reliable in Oshana region and indicated that students from Namibia do not have explicit inductive reasoning training in this age-range at school.

INTRODUCTION

In recent years, a large number of studies have highlighted the importance and benefits of technology-based assessment (TBA). A broad range of instruments is available, including observation protocols, tests and item banks, which can be used to assess different aspects of general cognitive development as well as specific skills such as scientific reasoning skills and inductive reasoning skills that learners are expected to master at school (Csapó et al. 2014; Pásztor et al. 2017; Wu and Molnár 2017). Namibia currently has a few mechanisms below the grade 12 end-of-school-year examination for measuring the performance of the system against international benchmarks (Ministry of Education 2007). There seem to be no effective mechanism for parents and other stakeholders to judge the performance of individual institutions. What is more, the end-of-school year examination does not fully address the assessment of reasoning skills at any level of schooling, despite calls to prioritize science, technology, and innovation in the country. In primary education, the only scientific and reliable assessment that attempts to measure students' reasoning and thinking skills are the Standardized Achievement Tests (SATs) that were introduced in 2009 (Iipinge and Likando 2012). However, these tests too fall short of assessing inductive reasoning skills in the broader sense of the concept (Csapó 1997), as they only assess students' achievement in the discipline of science upon completion of the Grade 7 science curriculum, and not on inquiry and thinking skills as needed for success in everyday life (Nemeth and Korom 2012). Few feedback mechanisms are in place to identify areas of pedagogical difficulty and current testing mechanisms are not well aligned with modern learning and the pedagogical demands of the twenty-first century. Beyond doubt, thinking skills are tools to success in today's society characterized by rapid change, where the nature of applicable knowledge changes frequently and specific contents quickly become outdated (De Konig 2000).

Namibia's Vision 2030 plan was released in 2004, aimed at the rapid economic growth necessary to transform Namibia into a developed country supporting a knowledge-based econo-

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my that will provide productive employment opportunities for the majority of its citizens by 2030. Since 2006, Namibia's Ministry of Education (MoE) has embarked on the Education and Training Sector Improvement Plan (ETSIP), a comprehensive plan developed by the MoE with the assistance of the World Bank to improve education as a means of meeting the goals of Vision 2030. The basic premise of the ETSIP is that the Namibian government must increase learning achievement in primary and secondary schools. The evidence (15th School Day Statistics 2013) shows that despite successes in primary school enrolment and completion, most children leave primary school without the foundational skills including competencies in literacy and numeracy and reasoning skills that they ought to have acquired (MoE 2010). A study entitled 'Namibia Human Capital and Knowledge Development for Economic Growth with Equity' (Marope 2005), conducted by World Bank experts as a precursor to the development of the ETSIP, found the following barriers to student assessment:

1. Namibia has too few mechanisms to measure the levels of achievement and performance of the school system, particularly at primary level.
2. The mechanisms to provide information to judge the performance of individual schools is not effective.
3. The mechanisms to identify teaching and learning difficulties and provide feedback and assistance to individual schools about mastering key skills and competences are insufficient.

To overcome these constraints in the assessment system, especially at the primary level, the Directorate of National Examinations and Assessment (DNEA) in Namibia was tasked with developing a sustainable, long-term assessment system, the Standardized Achievement Tests (SATs) (National Institute of Educational Development [NIED] 2008). However, the SATs only assess students on Mathematics, Science, and English in the 7th grade and on Mathematics and English in the 5th grade. Hardly any assessment of reasoning skills is involved.

It is against these backgrounds that the researchers undertook this research to see how students in Namibia perform in the inductive reasoning tasks and compare it with a small sample data from China as a benchmark. Chinese students regularly participate in the Program for International Student Assessment (PISA) and other international assessment programs, which Namibia is yet to take part in. According to the results of PISA 2012 and 2015, Chinese students have a high level of science literacy (OECD [Organization for Economic Corporation Development] 2014; OECD 2016; OECD 2017). In PISA 2012, Shanghai-China was ranked at number one, in science and mathematics assessment, and number six in problem-solving assessment (OECD 2014); and in PISA 2015, China (Beijing, Shanghai, Jiangsu, Guangdong) was ranked at ten in science and six in Mathematics, its performance remaining much higher than the average (OECD 2016; OECD 2017). Therefore, it can be safely said that Chinese students' inductive reasoning skills are among the best in the world.

Theoretical Background

Inductive Reasoning

Inductive reasoning (IR) is a general thinking skill related to almost all higher-order cognitive skills and processes (Csapó 1997). There is no universally accepted definition of IR, though several definitions have been proposed (Molnár et al. 2013). A classical understanding of IR is that IR is the process of moving from the specific to the general (Sandberg and McCullough 2010). That is to say, IR is described as the generalization of single observations and experiences in order to reach general conclusions. Our IR test is based on Klauer's (1990) definition of IR as discovering regularities by detecting similarities, dissimilarities, or a combination of both, with respect to attributes or relations to or between objects (Csapó et al. 2014).

In order to develop reasoning and thinking skills effectively, the researchers need to explore students' inductive reasoning abilities by means of assessment. Many studies have been conducted on students' inductive reasoning skills, mostly in developed countries; for example, the large-scale international assessments, Programs for International Student Assessment (PISA) and Trends in International Mathematics and Science Studies (TIMSS) (Bao et al. 2009; Han 2013; Mayer et al. 2014; OECD 2017). Unlike in China, these kind of studies are not yet known in Namibia, where the research focus is mostly qualitative, and hardly any research on general

assessment and the assessing of thinking and reasoning skills has been carried out.

Development of Inductive Reasoning Skills and the Namibian Primary Education

The fundamental role of the process of inductive reasoning for child development and its domain-independent applicability has been widely recognized (McShane 1991; Snow et al. 1984; Sternberg 1998; Sternberg and Gardner 1983). In Namibia, like elsewhere in the world, the preparatory phase (Pre and lower primary education phase, from 0-3rd grade) closely follows and stimulates the development of children (Csapó 1997). That is, educating students aims at supporting their gradual understanding of the world around them (De Koning et al. 2002). For example, education in the preparatory phase links with age-appropriate mental representations (Piaget 1970) and age-appropriate mental processing capacity (De Koning et al. 2002). Furthermore, the natural developmental mechanisms are supported by the equilibration process (Adey and Shayer 1994), causal reasoning (Goswami 1998), and automating of cognitive processing for freeing memory space. Examples of activities in the preparatory phase of primary education are classifying and seriating of blocks with respect to color, form, and number and discovering relationships such as action–reaction or cause–effect with lotto cards (De Koning et al. 2002). In Namibia, the following are some of the activities for the pre and lower primary phase education as found in the National syllabus:

1. Distinguish between and identify different sounds they hear in the environment
2. Notice small differences and similarities between environmental and verbal sounds
3. Repeat a sound pattern or clapping rhythm correctly
4. Repeat a sequence of 3-4 words correctly
5. Listen to stories, rhymes, and songs for enjoyment
6. Arrange pictures in the correct sequence
7. Participate in card, word and memory games
8. Observe the whole as a meaningful entity
9. Perceive objects in the foreground and the background and separate them meaningfully
10. Complete jigsaw puzzles up to 12 pieces
11. Observe a picture as an entity, to separate (break up) its parts logically and bring them together again to a meaningful whole (Namibia, Ministry of Education 2015).

These activities require students to order their environment by connecting units using the definition of laws and this is inductive reasoning (De Koning et al. 2002).

From the pre-primary and lower primary phase to the fourth grade of primary education onward, such general reasoning activities may not necessarily be part of the lessons. Instead, education becomes focused on reading, writing, science, and mathematics as well as environmental studies, which are considered to be the main requirements for participation in our national society and western world. This curriculum-oriented education is led by internal structures of specific domain knowledge (example, the syntax of the language and the metric system) and by the domain tied cognitive processes that underlie efficient learning (example, distinguishing nouns from verbs and counting) (Csapó 1997; Klauer 1996). Findings from research on learning and information processing provide methods as to how knowledge could best be sequenced and what instruction procedures would work well (De Koning et al. 2002).

The current style of transition from developmentally oriented education in the preparatory phase (pre-primary and lower primary) to curriculum oriented education from the fourth grade onward may rather be abrupt. There are increasingly more complex society demands people to handle huge amounts of information that becomes outdated quickly (Wu and Molnár 2017). Therefore, students should not only be taught considerable amounts of knowledge and skills for reading, writing, science, and mathematics, but they should also be equipped with general reasoning skills to order information processing (Hamers et al. 1998). This will enable students, to connect bits of information into meaningful representations and to distinguish relevant and irrelevant information for a particular task. This assertion is echoed by (Csapó 1997), inductive thinking, especially analogical reasoning, is a means of *transfer* - applying knowledge acquired in one context in new situations. Research has also found out that reading, writing, science, and mathematics performances are dependent on general reasoning skills (De Koning and Hamers 2016).

Technology-based Assessment

Expectations of the outcomes of education in the twenty-first century are increasingly focusing on the higher order thinking skills of synthesis, analysis and evaluation (Osborne 2013), yet school science education is still dominated by lower-level cognitive demands, in particular recall. Technology-based assessment has proved a promising innovation to overcome these problems. Nevertheless, it has its own constraints, such as the provision of basic technology infrastructure by the government and all the stakeholders involved in public education. Technology has great potential for assessing thinking skills because of its innovative item design and data processing capacity (Csapó et al. 2012a,b). This idea is in line with Namibia's Information and Communications Technology (ICT) policy introduced in 2001 (Ministry of Basic Education, Sport, and Culture 2001), whose purpose is "to prepare all Namibia's learners, students, teachers, and communities of today for the world economy of tomorrow". According to the policy, "as the researchers move towards a knowledge-based development paradigm integrating ICT education and training into the education and training system, issues of access to the local and global pool of knowledge and information become paramount" (Ministry of Basic Education, Sport, and Culture 2001).

Research Objectives

The main objective of this study was to examine the inductive reasoning abilities of Namibian students from the selected school in Oshana region and comparing it with data from a small Chinese sample as an indicative benchmark. The researchers also wished to explore the possibilities of online assessment in Namibia.

Hypotheses

Based on the background information, the following hypotheses were made:

Hypothesis 1

Technology-based assessment can be ***Feasible*** and ***Reliable*** in Namibia.

Since Namibia has never been involved in any international large-scale educational assessment projects that are based on the TBA before, it is necessary, first, to prove whether the online assessment is feasible and reliable in the Namibian context.

Hypothesis 2

Students' inductive reasoning skills grow along with their ***Grade*** progression.

Students' thinking and reasoning skills will grow with a good education. Education in Namibia effectively supports students to enhance their inductive reasoning skills.

Hypothesis 3

There is no significant difference in inductive reasoning skills test performance between genders.

Hypothesis 4

There will be the statistically significant difference in performance between the benchmark samples and the research samples from Namibia.

Namibian students have not yet had an opportunity to compete with international students. There is, therefore, no enough direct data to support this hypothesis so far. However, as pointed out above, China has been one of the top performers in the PISA 2012 and 2015 in mathematics, science and problem-solving assessment. In consideration of this situation, the researchers expect the benchmark sample (Chinese students) to perform better in inductive reasoning than Namibian samples.

METHODOLOGY

Research Context

The research took place in Oshana region (Namibia), where research participants were assessed in inductive reasoning skills tasks. Due to of lack of computer labs (ICT infrastructures) at the schools where the participants were from, students were ferried to nearby University of Namibia computer labs to write the test online. Although all the participants were from urban schools, no fully functional computer labs were found at these schools. If schools have com-

puters, the machines are either out of order or there is no reliable internet connectivity. The Electronic Diagnostic Assessment (eDia) platform was used to collect the data.

Participants

The sample of the study was drawn from the fifth and seventh graders (N=621; 268 boys; 348 girls; age M=12.40, SD=1.19) from five different schools. For grade 5, the sample was N=275 (121 boys; 152 girls, age M=11.19, SD=.68), while the grade 7 were 346 (147 boys; 196 girls, age M=13.23, SD=.61).

The Chinese participants (N=50; 27 boys; 23 girls) were in the same age group as the participants from Namibia (age mean=12.28, standard deviation (SD=.50). However, due to the different educational system, the Chinese participants were sixth graders, which is the last grade for the primary school, while in Namibia; the last grade of primary school is grade 7.

Instruments

The study was based on inductive reasoning skills (IR) that measure different thinking skills essential for learning in general and learning science. A background questionnaire, such as mothers' level of education was also given to students.

The IR test is based on Klauer's (1990) definition of IR as discovering regularities by detecting similarities, dissimilarities, or a combination of both, with respect to attributes or relations to or between objects (Csapó et al. 2014). See Figure 1 for Klauer's definition and genealogy of tasks in inductive reasoning.

The inductive reasoning test administered in Namibia consisted of 56 items, while the test prepared for Chinese samples contained 53 items. The two test versions contained 42 anchoring items, allowing achievement scores to be represented on a single scale. This enabled us to use the Rasch model to further analyze the results. The test is developed by Research Group on the Development of Competencies of the University of Szeged. The original test is in Hungarian, and consist of four subtests, which are figural series, figural analogy, number analogy, number series (Fig. 2) (Pásztor et al. 2017). The texts were translated from the Hungarian language into English and simplified Chinese. Figure 2 (Pasztor et al. 2017) shows the sample items from each sub-constructs.

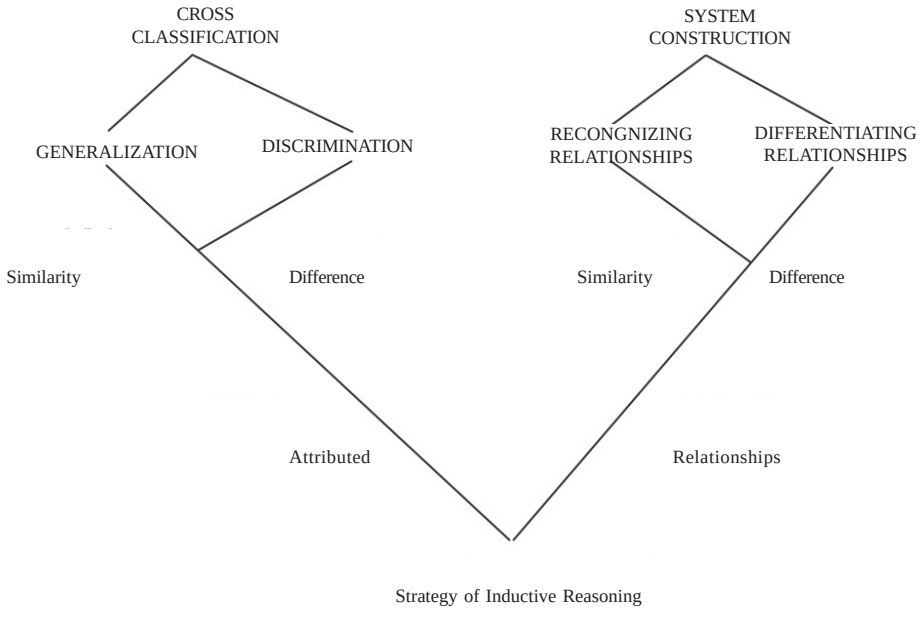

Fig. 1. Klauers' genealogy of tasks in inductive reasoning

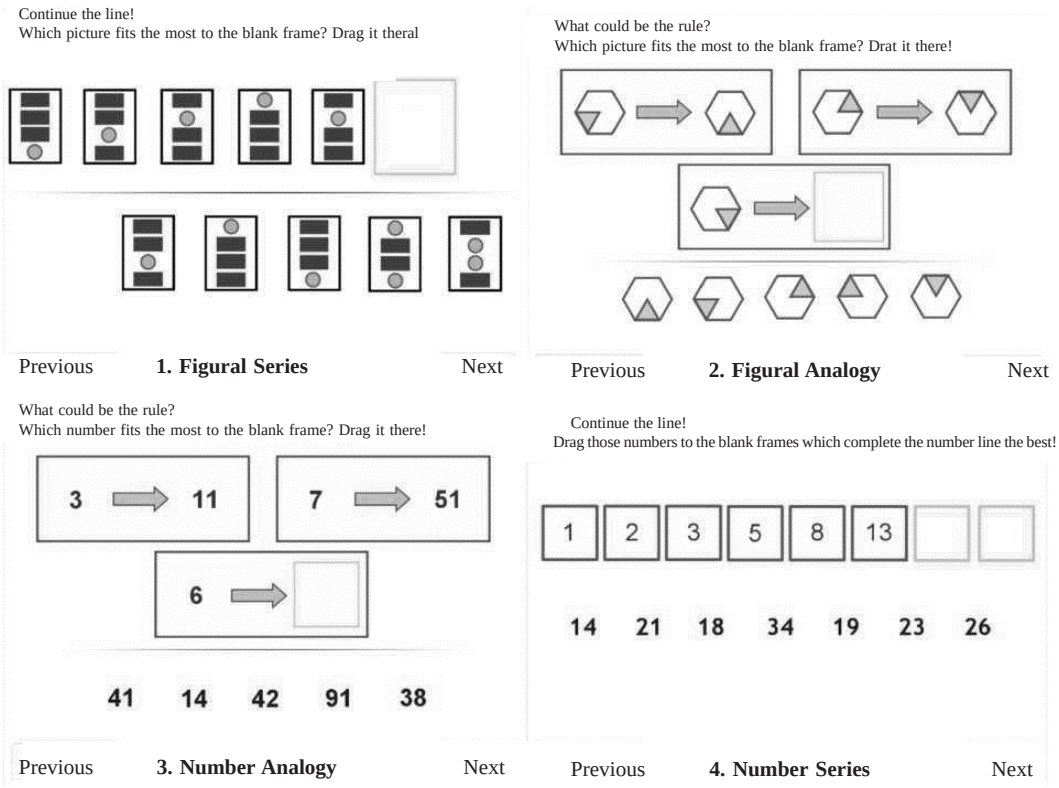

Fig. 2. Sample items

RESULTS

Psychometric Properties

The reliability for the assessment of the sample from Namibia was high (Cronbach alpha: 0.846). Participants' score distribution confirmed the applicability of the test, which proved that online assessment is feasible and reliable when conducted in Namibia. Thus hypothesis 1 has been supported by the results. The overall ability level of Namibian samples was low (Mean -1.38 and SD: 0.843). The maximum and minimum stood at 1.91 and -5.37 respectively. The grade five ability level mean was -1.44 and standard deviation (SD) was at 0.89, while the grade 7 ability stood at -1.32 and SD: 0.80. In terms of gender ability, the male mean was at -1.32 with the SD at 0.95, while the female ability level mean was -1.41, the SD is 0.72. In comparison, with the benchmark sample, the Cronbach alpha was .725, while the maximum and minimum scores were 4.56 and 0.70, respectively. The overall ability level mean was higher than that of the Namibian sample, 2.17, with SD of 0.828.

The Inductive Reasoning Development in Grade 5 and 7

Figure 3 shows the ability level growth for grade 5 and 7 samples from Namibia in inductive reasoning.

Figure 3 indicate that the samples' ability level in inductive reasoning at grade 7 was 0.124 higher than that of the fifth graders. No significant difference was found between the grades ($t=1.822$, $p>.05$) which means fifth graders and seventh graders achieved statistically equal performance in the assessment. Therefore, hypothesis 2 was not confirmed.

Comparison between Benchmark Samples

From the benchmark sample, Chinese samples produced a much better performance than

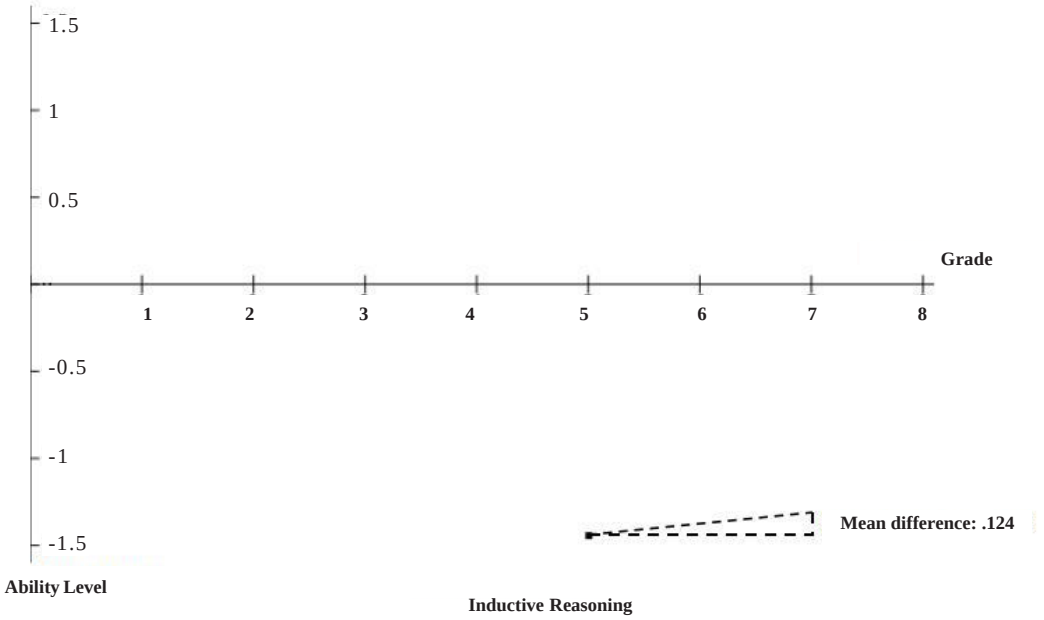

Fig. 3. Ability level growth in inductive reasoning

the Namibian samples. Chinese samples' mean ability level was 3.55 higher than that of Namibian students. The difference is extremely significant (t=28.684, p<.001). The benchmark samples found the items extremely easy while the research participants found the items extremely hard (See Fig. 4) Wright item person maps. For Chinese students, each 'x' represent 0.1 cases, the students from Oshana region, Namibia each 'x' represents 1.1 cases, and the numbers represent the item numbers on the test used. There were 42 anchoring items common to both assessments that enabled us to do this analysis). In addition, the differences between genders from both samples are reported in Table 1.

The best performing group in inductive reasoning was Chinese males' samples, followed by Chinese female's samples. Males performed better than the females in both samples, but there was no statistically significant gender difference in either sample.

Chinese students also performed significantly better on each subtest level (figural series: t=21.063, p<.001, figural analogy: t=16.469, p<.001, number analogy: t=18.859, p<.001 and number series: t=18.536, p<.001). Further analysis was conducted, whereby the samples' abilities were compared via different variables. A four-dimension comparison model was used (see Table 2) on the subtest level.

According to the model, Chinese samples showed significant better ability levels in every single subtest, which means hypothesis 4 has been strongly supported by the results. It is also worth noting that the Chinese samples performed extremely well compared to the research samples in numerical reasoning (number series and number analogy items). These results may be attributed to the good education system that China has in place. In the PISA tests, too, Chinese students have always outperformed other nations in mathematics- and science-related questions. As for the gender difference, in most cases, males' performance is better than females (except Chinese females are better than males are in the numerical analogy), but still there was no significant difference found. Therefore, hypothesis 3 was proved by the results.

DISCUSSION

The research aims were to examine the feasibility and reliability of technology-based assessment in Oshana region, and the students' abilities in inductive reasoning. As indicated above, the test showed high internal consistencies in

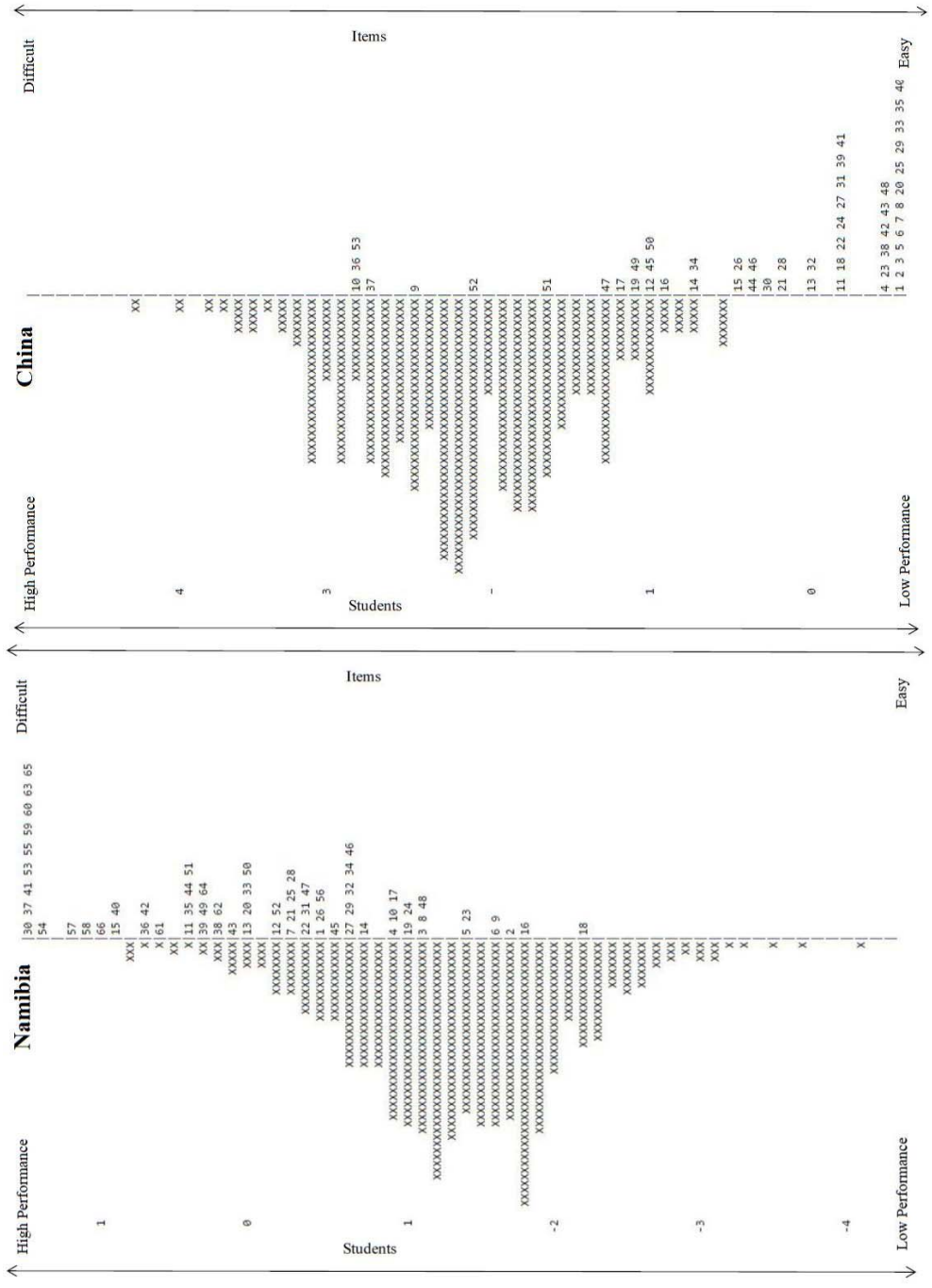

Fig. 4. Wright item person maps

Table 1: Comparison of inductive reasoning between genders

	Compare with	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*
1. Namibian males												
2. Namibian females	(1)	-.09 (.07)	-1.248	>.05								
3. Chinese males	(1)	3.55 (.19)	18.950	<.001	(2)	3.64 (.14)	25.263	<.001				
4. Chinese females	(1)	3.43 (.21)	16.684	<.001	(2)	3.51 (.16)	22.192	<.001	(3)	-.13(.24)	-.538	>.05

Namibia (Cronbach alpha for inductive reasoning: 0.846), which is a very good indicator for a starter. Consequently, research have indicated that the skills considered most essential in our modern societies are often called 21st century skills (Molnár et al. 2017; Csapó and Funke 2017). Problem solving is clearly one of them. Students are expected to work in novel environments, face problems they have never seen and apply domain-general reasoning skills such as inductive reasoning skills, which are not tied to specific contents (Pasztor et al. 2017). Computerized dynamic problem solving can be used to create such an interactive problem situation in order to assess these skills. It may therefore form the basis for a type of assessment, which helps answer the question of how well schools are preparing their students for an unknown future. This paper shows how education systems (specially the Namibian education system) may benefit from such an assessment. This proved that technology-based assessment is feasible and reliable in Namibia, even though some of the schools where the participants were from do not have adequate ICT facilities. The results of the studies conform to the current research communities that support the proposition that inductive reasoning develops during a broad age range and that the developmental process covers the whole period of elementary and secondary education (Csapó and Funke 2017; Kambeyo and Csapó 2017).

Furthermore, this result indicates that research participants may not have explicit inductive reasoning training in this age-range at school, which suggests that the education curriculum may need to look into this aspect of reasoning. The considerable low performance in the reasoning skills test can be attributed to school instruction, especially the mathematics skills acquired during the primary school years. The proportion tasks for figure and number analogies as well as figure series and number series and can be considered one of the basic forms of numeric or mathematics, however, the performance was low, see the results (overall mean ability). This is particularly so because research has indicated that this age range is the stage at which students can evince the fastest growth in their thinking and reasoning skills (Molnár et al. 2013).

CONCLUSION

Although the results may not be generalized, as this case was restricted to the Oshana

Table 2: Comparison of inductive reasoning on subtest level between nationalities and genders

Figural Series	*Compare with*	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*
1. Namibian males												
2. Namibian females	(1)	-.09 (.08)	-1.075	>.05								
3. Chinese males	(1)	3.31 (.22)	14.882	<.001	(2)	3.40 (.20)	17.400	<.001				
4. Chinese females	(1)	3.08 (.25)	12.564	<.001	(2)	3.17 (.22)	14.721	<.001	(3)	-.23 (.30)	-.774	>.05
Figural Analogy	*Compare with*	*Mean difference-(SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*
1. Namibian males												
2. Namibian females	(1)	-.12 (.10)	-1.169	>.05								
3. Chinese males	(1)	2.99 (.27)	11.130	<.001	(2)	3.11 (.22)	13.807	<.001				
4. Chinese females	(1)	2.76 (.29)	9.587	<.001	(2)	2.87 (.24)	11.945	<.001	(3)	-.23 (.30)	-.773	>.05
Numerical Analogy	*Compare with*	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*
1. Namibian males												
2. Namibian females	(1)	-.10 (.07)	-1.411	>.05								
3. Chinese males	(1)	3.74 (.28)	13.368	<.001	(2)	3.85 (.28)	13.827	<.001				
4. Chinese females	(1)	3.84 (.31)	12.557	<.001	(2)	3.94 (.25)	12.964	<.001	(3)	.09 (.41)	.228	>.05
Numerical Series	*Compare with*	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*	*Compare with*	*Mean difference (SE)*	*t*	*p*
1. Namibian males												
2. Namibian females	(1)	-.13 (.09)	-1.427	>.05								
3. Chinese males	(1)	4.00 (.31)	12.962	<.001	(2)	4.13 (.22)	13.515	<.001				
4. Chinese females	(1)	3.66 (.26)	14.169	<.001	(2)	3.79 (.18)	16.179	<.001	(3)	-.34 (.41)	-.823	>.05

region, the online assessment tool for inductive reasoning skills proved to be reliable as well as feasible in Namibia. The research participants mean performance was low, this suggests the need to try out the test in the older age group. In terms of gender performance, no statistically significant difference was found in either sample. The study was one of the first attempts to carry out an online assessment at primary school level in Namibia. The results indicate that technology-based assessment may provide schools and teachers a user-friendly instrument for monitoring the development of students' thinking skills.

The low performance and the low ability level of the research participants from Namibia as compared to the benchmark samples suggest that the Namibian primary education system needs to improve in enhancing students' inductive reasoning ability. Furthermore, the computerized test environment was probably unfamiliar to the research participants, but to what extent, that has not yet been established. However, there is empirical evidence to support the idea that this kind of test (inductive reasoning) is not affected by the medium involved.

RECOMMENDATIONS

Based on the results, the education system in Namibia should put emphasis on the development of reasoning and thinking skills. Improving reasoning skills has always been one of the most prominent goals of education, but practical constraints have stood in the way. However, research has shown that there are additional ways to significantly and effectively develop thinking skills, for instance, by explicit training of teachers or by enriching school materials and modifying teaching and instructional methods. For that reason, it might be useful to devise a training program in inductive reasoning in Namibia. Further research in Namibia in this aspect is encouraged, and it should have more sample for the results to be representative. Given the fact that China has always performed exceptionally well in reading, science, and mathematics in international assessment programs such as PISA and TIMMS, the Namibians might also learn a thing or two from the Chinese education system, so as to improve and enhance the reasoning and thinking skills of the Namibian child.

Educational Implications

The present study contributes to the recently re-opened debate on the role of general-purpose and cross-curricular abilities in achieving successful participation in the 21st century's western society and on the limitations associated with understanding only specific abilities such as reading, writing, and math. The potential lying in reasoning skills such as inductive reasoning and problem-solving as educationally relevant constructs that can and should be fostered successfully over several years during compulsory schooling.

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