To What Extent was the Updated Content of Education Useful for Kazakh and Russian Child Numeracy and Literacy Development? An Examination via Multilevel Modelling

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THE UCE AND CHILD NUMERACY AND LITERACY DEVELOPMENT

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NU GSE Research Approval Decision Letter

53 Kabanbay Batyr Ave.

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October 2022

Dear Assel Zholymbekova,

This letter now confirms that your research project entitled: The Role of the Updated Content of Education on Kazakh and Russian Child Numeracy and Literacy Development: An Examination via Multilevel Modelling, has been approved by the Graduate School of Education Ethics Committee of Nazarbayev University. The Committee agreed that your research does not involve the participation of human subjects, and therefore you might proceed with your study.

Yours sincerely,

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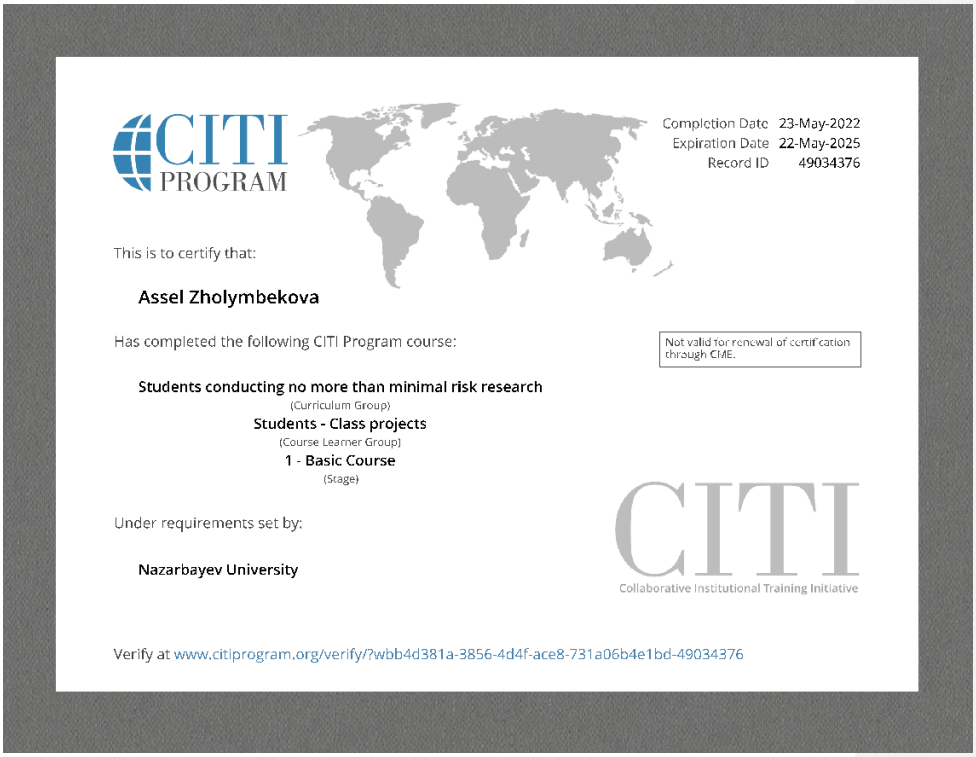

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ABSTRACT

To What Extent was the Updated Content of Education Useful for Kazakh and Russian Child Numeracy and Literacy Development? An Examination via Multilevel Modelling

This study aimed to investigate the effects of an updated curriculum on the literacy and numeracy development of Kazakh and Russian children. A quasi-experimental design was employed, and a total of 1,723 students from 28 schools were included in the study. The study made use of several multilevel parallel linear growth models to examine the effect of the updated curriculum on the developmental trajectories of child numeracy and literacy for children in Grades 1 to 3. An examination of within-school effects suggested that children who started school at a lower level of literacy improved at a faster rate. This suggested that schools may provide better conditions for lagging students, rather than facilitating students with initially high academic performance. However, an examination of between-school effects suggested that the schools that received children with higher average levels of numeracy and literacy tended to support students to exhibit a slightly higher level of average progress. Finally, and the key finding of this study, schools that adopted the updated curriculum tended to support children to develop numeracy and literacy at a much higher rate than schools that adopted the traditional curriculum, and this advantage was equivalent for both Russian and Kazakh speaking children. Incidental findings also suggest that children with more educated mothers and kindergarten experience tended to begin school at a higher level of numeracy and literacy compared with classmates, though children developmental rates tended to not be associated with their demographic characteristics. However, the study has several limitations, such as the uneven size of the experimental and control groups. Despite these limitations, the study provides valuable insights into the impact of updated education content on child development

and the curriculum itself should be viewed as a valuable contribution to the research on child development and education.

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Аңдатпа

Жаңартылған білім беру мазмұны қазақ және орыс тілдерінде білім алатын балалардың математикалық және сауаттылық дағдысын дамыту үшін қаншалықты пайдалы болды? Көп деңгейлі модельдеу арқылы зерттеу.

Бұл зерттеу жаңартылған оқу бағдарламасының қазақ және орыс тілді білім алатын балалардың сауаттылығы мен математикалық қабілетін дамытуға әсерін зерттеуге бағытталған. Жобада квазиэксперименттік әдіс қолданылды. Зерттеуге 28 мектептен барлығы 1723 оқушы қатысты. Алынған деректер төрт даму сатысы бар көпдеңгейлі бөлшектік модельдерді пайдалану қазақ және орыс тілді сыныптар үшін деректерге ең жақсы және ең қолайлы сәйкестікті қамтамасыз ететінін көрсетті. Мектепішілік үлгі сауаттылығы төмен мектепке түскен оқушылардың сауаттылығы жоғарырақ мектептерге қарағанда жақсырақ нәтижеге қол жеткізгенін дәлелдеді. Мектептер оқу үлгерімі жоғары оқушыларға емес, үлгерімі төмен оқушыларға көбірек мүмкіндік жасайтыны зерттеу барысында белгілі болды. Мектепаралық модель бастапқы сауаттылығы жоғары мектептердің бастапқы сауаттылығы төмен мектептерге қарағанда жоғарырақ көрсеткішке жететінін көрсетті. Ақырында, жаңартылған оқу бағдарламасының қазақ тілі мен орыс тілінде білім беретінмектептерге бірдей әсер еткені анықталды. Дегенмен, зерттеудің бірнеше шектеулері бар, мысалы, эксперименттік және бақылау топтарының көлемінің тең емес. Осы шектеулерге қарамастан, зерттеу жаңартылған білім беру мазмұнының баланың дамуына әсері туралы құнды ақпарат береді және баланың дамуы мен білімін зерттеуге құнды үлес ретінде қарастырылуы керек

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Аннотация

Насколько было полезно обновленное содержание образования для развития навыков счета и грамотности у детей с казахским и русским языков обучения? Исследование с помощью многоуровневого моделирования.

Это исследование было направлено на изучение влияния обновленной учебной программы на развитие грамотности и счета у детей в казахских и русских классах. В исследовании был использован квази-экспериментальный дизайн, и принимали участие 1723 ученика из 28 школ. Полученные данные показали, что использование многоуровневых моделей с четырьмя стадиями развития обеспечило наилучшее и наиболее подходящее соответствие данным для школ с казахским и русским языком обучения. Школьная модель предоставила доказательства того, что учащиеся, поступившие в школу с низким уровнем грамотности, улучшают успеваемость лучше, чем те, кто начинает с более высокого уровня грамотности. Школы способствуют улучшению условий для отстающих учащихся, а не учащимся с изначально высокой успеваемостью. Межшкольная модель показала, что школы с высоким уровнем начальной грамотности развиваются лучше, чем школы с более низким уровнем начальной грамотности. Наконец, обновленная учебная программа оказала значительное положительное влияние на темпы роста между школами как для казахских, так и для русских школ. Однако у исследования есть несколько ограничений, таких как разное количество принимающих участие в экспериментальной и контрольной группах. Несмотря на эти ограничения, исследование дает ценную информацию о влиянии обновленного образовательного контента на развитие ребенка, и его следует рассматривать как ценный вклад в исследования развития и образования детей.

ABBREVIATIONS

MOI: Medium of Instruction.

LOI: Language of Instruction.

MOE RK: Ministry of Education of the Republic of Kazakhstan.

UCE: Updated Curriculum of Education.

CPM: Center for Pedagogical Measurement.

ICC: Intra-class Correlation Coefficient.

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I. Introduction

Early education for children plays a crucial role in setting the foundation for a child's academic journey. The literature suggests that primary-level education holds greater potential for generating higher returns in adulthood compared to secondary-level education due to the formation of essential cognitive skills during the early years (OECD, 2012, p. 3). According to Heckman (2011), there is compelling evidence that allocating resources towards early childhood education leads to substantial economic productivity in adulthood. Specifically, for each dollar invested in this stage of development, an estimated seven to ten cents worth of economic productivity is generated annually per individual.

Both student- and school-level demographic and experiential factors are known to influence the growth and development of children in the early years of school. While student demographics vary naturally within schools, school infrastructure and teaching approaches vary between schools, and these factors are typically considered by parents when selecting appropriate schools for their children. Parents in Kazakhstan attach great importance to the language of instruction (LoI), as both Kazakh and Russian languages are officially recognized and play a crucial role in shaping national and regional Kazakh identity (MoERK, 2019).

Commented [A1]: What is the difference between LoI and MoI?

This study aims to investigate the impact of the Updated Content of Education (UCE) on numeracy and literacy development in elementary schools that use Kazakh and Russian as the medium of instruction between 2015 and 2017. While previous studies have explored the impact of the updated curriculum on literacy, numeracy, and science development separately for each medium of instruction (MoI), this study specifically examines whether the UCE had equivalent positive effects on child numeracy and literacy development for both Kazakh and Russian languages. Specifically, this study seeks to contribute to the literature by examining the comparative utility of the UCE for child literacy development in both Kazakh and Russian, with the goal of informing policy and practice for future reforms.

1.1 Background Information

In the 2020-2021 academic year, a total of 2,275,100 students received their education primarily in the Kazakh language, whereas 1,206,300 students primarily received theirs in the Russian language (Baikozha, 2021). Therefore, for the 2021-2022 academic year, for every student learning in Russian, there were 1.89 students learning in Kazakh. While this suggests that the Kazakh language is currently prominent, it actually reflects the lowest proportion of student use of the Kazakh language of instruction for the last seven years. Aldabegenkyzy (2020) argues that an increasing number of parents in Kazakhstan now prefer Russian as the language of instruction for their children, as they believe that fluency in Russian is essential for achieving social success. Additionally, the perception that Russian is associated with intellectual capital has an impact on parental decision-making regarding language of instruction. In contrast, Ahn and Smagulova (2016) suggest that parents who prefer Russian-medium schools lack a commitment to the revival of the Kazakh language. Some parents do choose Kazakh-medium schools out of a sense of national pride and the belief that every Kazakh should learn their mother tongue.

Despite a growing youth population in Kazakhstan, the number of Kazakh-medium schools has only increased by four since 2014 (Ministry of Education of the Republic of Kazakhstan, 2021). The majority of schools in the North regions of Kazakhstan now offer Russian as the medium of instruction, with only 21% of over 8,000 students attending Kazakh-medium schools in 2021 in that region. In Petropavl, there are six Kazakh and 31 Russian schools, illustrating the high demand for Russian-medium schools and low demand for Kazakh-medium schools. This trend challenges the government of Kazakhstan, which aims to increase the number of Kazakh-speaking citizens by 95% by 2025. If this trend continues, the status of the Kazakh language as the main language of communication and documentation in Kazakhstan may be at risk.

There are numerous reasons why parents choose to enroll their children in Kazakh MOI schools. Ainur Muratkyzy carried out a multilevel analysis in 2020 to investigate the factors influencing the reading literacy performance of 15-year-old students in PISA. Through her quantitative research, she discovered that students studying in schools where the predominant language spoken is Russian had a literacy advantage equivalent to three years of education compared to those studying in schools where the predominant language is Kazakh. However, Muratkyzy's research only focused on secondary school students, and there is very little information about the potential difference in language literacy between Kazakh and Russian-speaking elementary school students in Kazakhstan. One of the goals of this study is to determine the impact of the language of instruction, i.e., Kazakh versus Russian, on the development of child numeracy and literacy in early elementary school.

1.2 Problem Statement

To address issues in school education, Kazakhstan's government introduced a pilot program in 2015 called the Updated Curriculum of Education (UCE). The UCE aimed to implement various practices, including learner-centered teaching, criterion-based assessment, and modernized resources. Teachers received training and were expected to implement the new curriculum. A study by Dimitrov et al. (2020) examined the UCE's effectiveness in improving student performance in math and science over five years. The researchers found that the UCE had a more positive impact than the traditional curriculum. As a result, they recommended that the government and schools focus on training teachers in the UCE's unique features, such as professional and pedagogical competencies, teaching aids and materials, and criterion-based assessments.

While the Dimitrov et al. (2020) study suggested that the UCE had a positive impact on rate of academic improvement in Math and Science, the Courtney et al. (2022) study investigated the impact of the UCE on students' rate of academic improvement in child

Kazakh, Russian, and Uyghur literacy. The researchers found that implementation of the updated curriculum of education had a positive impact on Kazakhs and Russian speaking students, especially in the first stages of the five-year study. Specifically, the study revealed that the introduction of the new textbooks and the application of formative assessment and communicative language teaching (CLT) methods are likely to enhance Kazakh and Russian child literacy. Other findings of the study revealed that while female students started the study ahead of their male classroom counterparts, they still progressed at the same rate over the course of the five-year study. The research also illustrated that, for Kazakh language development, children in Grades 3, 4, and 5 demonstrated a faster rate of literacy development than children in urban locations. The authors speculate that this may have been associated with more opportunities to use the language in context and consequent possible improvement in syntactic development in this developmental period. Taken together, the Courtney et al. (2022) and Dimitrov et al. (2020) studies suggest that the UCE had a general positive influence on child literacy, mathematical, and scientific development. However, whether the UCE was equally beneficial for both Kazakh and Russian child numeracy and literacy development is yet to be explored in the literature.

1.3 Purpose of the Study

One important feature of the 2015 to 2019 pilot study was that the test items were equivalent for Russian and Kazakh languages only for the 2015 to 2017 period. Specifically, during this early period of the pilot, each test question tested the very same aspect of numeracy and literacy and the test instruments were considered equivalent across the two key languages. Given these test conditions, it is possible to identify the effect of (1) the UCE, (2) the LOI, and (3) the interaction between the UCE and the LOI on the rate of child academic improvement in numeracy and literacy for the first three years of the study. It is conceivable that the UCE might be less useful for the development of child literacy in Kazakh (or vice-versa), though

this is yet to be explored in the literature. If it were the case that the UCE provided a non-equivalent level of advantage to one language group, then further more careful analysis of why this may have been the case would be necessary. Furthermore, given the need to provide optimal learning conditions for children in early schooling irrespective of LOI, any future curricula updates may be informed by the results of the current study.

The following chapter provides a comprehensive review of the literature on the topic. Thereafter, the methodology chapter will detail the methods employed to answer the research questions in this study. At this juncture, the results are presented. Thereafter the study presents a discussion of the results and provides implications for policy and practice in Kazakhstan.

1.4 Research Questions

RQ1: Under the (1) traditional school curriculum, and (2) UCE, what is the level of (a) numeracy and (b) literacy of the (i) Kazakh- and (ii) Russian-speaking children for the three-year monitoring period?

RQ2: What is the (1) initial status and (2) growth rate of (a) numeracy and (b) literacy of the participating children?

RQ3: What is the effect of the (1) language of instruction and (2) pilot UCE on the (a) initial status and (b) growth rate of students' (i) numeracy and (ii) literacy?

RQ4: Is there any interaction between the (1) language of instruction and (2) the pilot UCE on the (a) initial status and (b) growth rate of students' (i) numeracy and (ii) literacy?

1.5 Significance of the Study

The study is significant because it aims to examine the impact of the Updated Content of Education (UCE) on numeracy and literacy development in elementary schools that use Kazakh and Russian as the medium of instruction. The findings of this study can have important implications for policy and practice in Kazakhstan, as they can inform future reforms and educational practices. The study also highlights the importance of early education in setting

the foundation for a child's academic journey and the potential economic productivity generated by investing in early childhood education. Furthermore, the study recognizes the importance of language of instruction in shaping national and regional identity, which can have implications for educational policy and practice in multilingual countries.

1.6 Summary

This chapter discussed the current state of language of instruction in Kazakhstan, with a focus on the increasing preference for Russian over Kazakh in schools. It also highlighted the government's aim to increase the number of Kazakh-speaking citizens and the potential risks to the status of the Kazakh language if this trend continues. The chapter then discussed the Updated Curriculum of Education (UCE) pilot program and its positive impact on academic improvement in math, science, and child literacy. However, the impact of the UCE on Kazakh and Russian child numeracy and literacy development has not been explored in the literature. Therefore, the purpose of this study is to investigate the impact of the UCE on the development of child numeracy and literacy in early elementary school, specifically in the Kazakh and Russian languages.

II. Literature Review

2.1 Introduction

This chapter provides a review of the literature associated with several aspects of topic under consideration. The first section introduces the literature review and how it is organized. The second section provides an overview of the Kazakhstani socio-linguistic context and its trilingual aspirations. The section achieves that by (1) describing instances where other countries have had to manage multiple minority, regional, and global language pressures, (2) discussing when it might be most appropriate to introduce non-mother-tongue LOI to children, and (3) detailing the unique Kazakhstani context. The third section provides a review of curricula reforms in Central Asia and their influence on child learning. The section reviews the curriculums for elementary schools in several Central Asian countries such as Uzbekistan, Kyrgyzstan, and Tajikistan. At this juncture, the fourth section provides a review of the common predictors of student academic performance in literacy and numeracy. For this section, predictors are categorized as varying within- or between-schools. Within-school variables such as gender, years of education in kindergarten, family size, family marital status, parental job status and parental involvement are discussed. Between-school variables shown to be associated with student academic performance in numeracy and literacy, such as school rural/urban location, school type (small/gymnasium/lyceum), school size, school gender composition, and school medium-of-instruction are also given due attention. These aforementioned within- and between-school variables constitute important control variables in the current study. For example, it is key to tease out the unique advantage that the UCE might afford to schools while controlling for systemic school-level attributes such as school location and school type. The final sixth and seventh sections provide a summary of the literature reviewed in the current study and, finally, a rationale for the research questions to be addressed in the current in investigation.

2.2 Characteristics of the Literature Review

Cooper's (1998) framework provides a comprehensive and structured approach for organizing and synthesizing knowledge in literature reviews. This framework comprises six defining characteristics, namely Focus, Goal, Perspective, Coverage, Organization, and Audience. In the present manuscript, research outcomes are reviewed as part of the Focus, with an emphasis on summarizing key research outcomes and drawing conclusions based on these findings. The Goal of the manuscript is to critically analyze relevant research in the field and to identify central issues related to numeracy and literacy outcomes of children. To achieve this goal, key variables related to student and school attributes of focus in the current study are south after and reviewed.

The Perspective adopted in this review is one of neutrality, with an attempt made to review available literature in an unbiased way in order to provide a general picture and understanding of common trends in the field of interest. The Coverage of the thesis project is central and pivotal, with every article, book, or thesis related to the topic of study reviewed (with a focus on findings in Kazakhstan and Central Asia). Selection of the literature was also based on certain criteria such as articles being derived from Scopus indexed journals with a 'Q' ranking and being less than 30 years old.

In terms of Organization, the literature review is structured in a clear and logical conceptual manner that reflects Cooper's framework. Specifically, the literature review begins by providing a broad conceptual understanding of the linguistic aspirations of the people of post-colonial societies and Kazakhstan, though concludes with a narrower focus on child- and school-level factors shown to be associated with individual and institutional improvement in numeracy and literacy.

Finally, the focal Audience of the review is general scholars, practitioners, and policy makers interested in how reform practices might function for indigenous and regional child language groups. The findings of the review may be of interest to scholars and policy makers looking to understand the systemic effects of educational reforms, and the implications of such reforms on the academic outcomes of children in different linguistic contexts.

2.3 Minority, Regional, and Global Language Aspirations

In numerous nations, including former colonies and those with a regional language used as a lingua franca, children face varying demands to learn in multiple languages. These demands stem from the need to (1) foster a unified national identity that transcends ethnicity and culture, while also (2) promoting broader integration into the regional socio-economic landscape.

This discussion begins with a look at the international literature on the pressures associated with both government provision of and parental decisions for the language of instruction (LOI) for children in schools. Like Kazakhstan, other countries also experience pressures to provide child schooling using multiple LOI. A review of such literature helps to inform the general context and pressures in Kazakhstan. One of the factors affecting parents' choice of LOI for their children is the availability of textbooks in Kazakh language. According to the experts, "the textbook provision in Kazakh language in the field of natural-technical and engineering sciences constitutes merely 10%" (Kabuldinov, 2009, para. 18). (p. 16). It is also important to note that, scientific textbooks in the Kazakh language are translated mainly from Russian. At times, parents may have trouble comprehending the content of primary school textbooks because of inadequate translation or insufficient use of terminology in the Kazakh language. Therefore, they prefer the Russian MOI. This problem of native language provision at schools in not only inherent to Kazakhstan. Other post-colonial states also face such issues, which will now be discussed.

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Africa has experienced multiple pressures to deliver child education in different LOI. For example, Chavez (2015) has conducted research on the pressures associated with LOI in Namibia and the shortcomings associated with imposing non-mother-tongue LOI in schools in early elementary school. To give an instance, in Namibia, even though English is the language of instruction in primary school, a significant percentage of students lack functional literacy in English and have numeracy skills below the required level. According to Chavez (2015), a study found that students who are proficient in their native language tend to be better at learning other languages. Consequently, the Namibian government introduced African languages as the medium of instruction in lower primary grades. However, some parents prefer their children to be taught in English as they believe that English-speaking teachers are more qualified. The problem is that a vast majority of teachers in Namibia are not proficient in basic English, which can affect the academic performance of students. Chavez (2015) argues that teaching in English alone can exclude a part of Namibian citizens from learning, and not providing instruction in their mother tongue in lower primary grades can have a negative impact on the education of the country's children. In 2010, nearly half of the 16-year-old students failed the junior secondary school certificate, which indicates the adverse effects of the English-only policy (Chavez, 2015, p. 194). Therefore, government policy needs to be sufficiently aligned with the capacity for teachers to delivery curricula content in a coherent and fluent manner. Nevertheless, if teacher training, teacher competence, and curricula content are lagging behind, this will have detrimental effects on early child numeracy and literacy development.

A Kuwait-based study on English as the medium of instruction in schools found that English has become a second language of sorts, as it is considered prestigious. Many parents choose to enroll their children in private bilingual or English Medium of Instruction (EMI) schools due to this perception. The researcher conducted a mixed-method study to understand why parents choose EMI, private bilingual, or public Arabic Medium of Instruction (AMI)

schools. The study involved a survey completed by 71 parents, which included questions on reasons for their choice and a proficiency rating scale for Arabic and English. The qualitative component of the study involved interviews with two parents from each of the three educational systems in Kuwait. The study revealed that the quality of education and convenience were the two main factors that influenced parents' decisions. Since English private schools are believed to deliver better education, many parents prefer them. However, the author argues that citizens need to have a strong grasp of Arabic before achieving excellent English proficiency. This issue is not unique to Kuwait, and marginalization of historical languages is a common thread throughout African, Arabic, and post-Soviet regions.

We now shift our focus to some of the research carried out in the Western world. In 2014, Paula Elosua Oliden and Josu Mujika Lizaso conducted a study to investigate the impact of family language and testing language on reading literacy in bilingual communities. The researchers utilized data from the PISA 2009 assessment, which involved 5,726 fifteen-year-olds. The study was conducted in Spain, specifically in a region where Basque was the official language, and only students who spoke Basque or Spanish at home and were Spanish were included in the study. The results of the study showed that students who spoke Spanish at home and took the test in Spanish achieved higher scores in reading comprehension. Interestingly, no difference in reading literacy was observed between Basque-Spanish and Basque-Basque mother-tongue/test language pairs.

To sum up, a large proportion of research suggests that mother tongue LOI should be given a priority over the second language in elementary schools. Though, Kazakhstan itself represents a unique case where many families use both Russian and Kazakh at home. In this sense, the meaning of “mother tongue” is blurred. Moreover, the preference of LOI in schools may not only be tied to socio-economic status, language status and prestige, but also to

nationalistic sentiments and commitment to Kazakh language revival (Terlikbayeva & Menlibekova, 2020).

In 2012, President Nazarbayev stated that the instruction of Kazakh language should be targeted towards younger generations. Nevertheless, parents have the freedom to decide which language their children are taught in and it is still common for most Kazakhs to choose Russian-medium schools. Despite this, as previously mentioned, only a little over half of the schools in Kazakhstan (65.5%) actually use Kazakh as the language of instruction.

According to statistics of National Bureau of Statistics of Agency of Strategic Planning and Reforms of the Republic of Kazakhstan, in 2022, there were 7,550 schools in Kazakhstan. In 3,700 schools, students are taught in Kazakh, while 1,200 schools employ the Russian LOI, and over 2,000 schools use mixed Kazakh-Russian MOI. Nevertheless, it is important to ensure that children in Kazakhstan, despite the LOI that they receive, experience the most appropriate instruction and pedagogical support to develop their numeracy and literacy in elementary school. With this goal in mind, recent curricula reforms have attempted to modernize the Kazakhstani curriculum. Hence a review of the recent curricula reforms and trends in Central Asia and Kazakhstan will now be provided.

2.4 Curricula Reforms in Central Asia

The newly introduced UCE in Kazakhstan aimed at improving the literacy and numeracy skills of school children. To do this, the curriculum proposed a shift to the student-centered approach of teaching rather than teacher-centered approach, a more comprehensive integration the ICT tools into lessons, the use of modernized textbooks, and the building of a more interactive and communicative relationship with students. The pilot program, involving a large sample of schools and students across the country, lasted from 2015 to 2019. While the studies by Courtney et al. (2022) and Dimitrov et al. (2020) provide some empirical evidence

of the utility of the UCE, other qualitative research conducted after the pilot was completed provides further insight. Findings from these studies will now be reviewed.

According to Tajik et al. (2021), rural students in Kazakhstan claimed that the updated curriculum helped them to be engaged in "independent learning, critical thinking, and creativity" (p. 2). In addition, Tajik et al. found that "School principals and head of the departments believed that the updated curriculum helps to improve students' functional literacy skills and other skills as well" (p. 3). However, a comprehensive empirical examination of the degree to which the recent curricula reforms provided equivalent advantage for the development of Kazakh and Russian child literacy is yet to be undertaken.

The curricula of other post-Soviet Central Asian countries are similar to that of the Kazakhstani primary school curriculum, but still each state has implemented some minor changes. For example, in Tajikistan, the primary classes start from the age of seven. Despite that, 90% of first graders do not undergo a pre-school preparation program. In 2008, testing of 4th grade students in Tajikistan revealed that only 54.6% coped with basic tasks in mathematics and in their native language. The Ministry of Education of Tajikistan aims at including the mastering new types of educational activities, starting conditions, and levels into the new primary school curriculum. However, unlike in Kazakhstan, the Russian language does not have an official status in Tajikistan. In spite of this, students have 2 to 3 hours of Russian language lessons per week in primary classes (Tajik et.al, 2021, p.5).

The elementary school curriculum of Uzbekistan is similar to the Kazakhstani one: starting from this year in both countries, the Russian language is not taught in the first grade, and constitutes only two hours a week in subsequent years. This year, the government of Uzbekistan cut the workload of primary schools by 10 hours and decided to focus on effectiveness and quality rather than quantity (Tajik et.al, 2021, p.6).

The Kyrgyzstani curriculum is similar to that of Kazakhstan's and Uzbekistan's school curriculum. The basic curriculum provided by the Ministry of Education allows schools to implement it with a 15% deviation. In Kyrgyzstan, the teacher workload in the first grade is 20 hours per week and 22 in the 2nd Grade, 24 in the 3rd grade, and 25 in the 4th Grade. Unlike in Uzbekistan and Kazakhstan, in Kyrgyzstan, the Russian language is taught in all primary classes three times a week (for one hour each). In contrast, in Russian schools, the Russian language is taught 6 to 7 hours a week (Tajik et.al, 2021, p.7).

Overall, the curricula of post-Soviet countries are similar. The schools usually provide 11 years of education and children start school at the age of 6 or 7. In primary classes, all of the aforementioned post-Soviet states provide the Russian language along with their native titular languages. The Kyrgyz, Uzbek, Tajik, and Kazakhstani ministries of education are now focusing more on modernizing the teaching process and integrating and applying ICT tools into learning. Given the contextual similarities, it is reasonable to assume that the findings for the current study in Kazakhstan may also be relevant and of interest, at least to some degree, to neighbouring post-Soviet countries.

2.5 Factors Associated with Child Literacy and Numeracy

This section provides a review of the various factors that research suggests have been associated with student literacy and numeracy. This section is broken in two general subsections: student- and school-level factors.

2.5.1 Student-Level Factors

Numerous studies have explored the connection between individual student characteristics and academic achievement (Muratkyzy, 2020; Wen et al., 2012; Oliden & Lisazo, 2014). However, this section of the literature review focuses specifically on the research related to the student-level factors examined in the current study. The purpose of this is to gain insight into what can be expected in the results of the current study and to provide a

set of studies that can be compared to the findings of the current study. While the main objective of this study is to investigate the impact of the UCE on the literacy and numeracy development of Kazakh and Russian-speaking children, the study also considers several other student-level covariate variables, which are of research interest. These include child gender, years of education in kindergarten, family size, family marital status (single vs. married), parental education level, parental job status, and parental involvement. The effects of these variables on learning are of both public and academic interest. Since these factors are part of the secondary data analysis, it is important to review the research related to these student-level variables. The following six subsections provide a literature review of the role of these specific student-level variables in student numeracy and literacy development.

2.5.1.1 Child Gender

In elementary school, gender plays a significant role when students just start to acquire reading literacy and numeracy skills. Numerous findings suggest that girls generally exhibit improved reading skills whereas boys often have some advantage in early numeracy (Fredriksson et al., 2009). This statement is supported by the multiple studies conducted since the 1970s in which girls consistently exhibited better results in reading comprehension than boys (Fredriksson et al., 2009). Studies in Kazakhstan also support this general notion. For example, findings from the Courtney et al. (2022) study suggested that females started school at a statically significantly higher level of Kazakh literacy than their male classmates (0.26 logits, $p < .001$). The same effect was apparent for Russian (0.31 logits, $p < .001$), while there was not any advantage enjoyed by males or females studying in Uyghur schools. More importantly, while being female appeared to provide some level of literacy advantage for females at the very beginning of school, gender had no association with the rate of growth for the first four years of elementary school education. While the rate of literacy development might be equivalent, studies have also suggested that the slight female advantage in literacy is

also apparent at secondary school. For example, Muratkyzy (2020) found that females were also 22 scale score points (*SD* = approximately 100 scale score points) ahead of their male class counterparts, and that a predominance of males in schools was also associated with lower levels of literacy in schools. Conversely, though the predominance of males in schools had no substantive effect for entry levels of literacy nor rate of improvement of elementary school children in Kazakhstan (Courtney et al., 2022).

2.5.1.2 Years of Education in Kindergarten

There are different scholarly works about the impact of attending kindergarten on the early academic performance of children at school. One study conducted in the United States examined the effectiveness of the Head Start early education project for one year and in two years attendance at kindergarten. The outcomes of the research revealed statistically significantly higher reading and numeracy skills, social skills, composite academic skills, and preschool learning behaviours in children who underwent the program, two-year post program (type of downstream effects) (Wen, et.al, 2011). In contrast, Datar (2003) explored whether more years at kindergarten led to better academic attainment at elementary school. Conversely, the researcher's work illustrated that the children who attended kindergarten at an older age gained higher scores in reading, math, and general knowledge tests during the first two years of schooling. The researcher proposed that parents delay the entrance of the children to kindergarten (Datar, 2003). Therefore, there exists some debate about how the number of years of education in kindergarten affects the academic performance of a child at school. The same research design and statistical approach was used to estimate the effect of kindergarten entrance age on math, reading, and general knowledge, while controlling for child poverty status, disability status, and gender (Datar, 2003).

The findings of the study revealed that the impact of entrance age varies remarkably by poverty status—children whose parents were below the poverty line were far less likely to

attend kindergarten (Datar, 2003, p. 45). The role that early exposure to kindergarten has on the developmental track of children in Kazakhstani elementary schools is yet to be investigated empirically in the literature.

2.5.1.3 Family Size

Deborah A. Cobb-Clark and Julie Moschion's (2017) study examines how the size of a family affects the academic performance of eight- to nine-year-olds and 10- to 11-year-olds in Victoria, Australia. The findings of the study suggest that having more than one sibling has a negative impact on a child's academic achievements. For instance, in reading, having more than one sibling results in a decrease in achievement of approximately 29% of a standard deviation according to standardized test scores, 33% according to teachers' persepctives, and 14% according to parents' perspectives (Cobb-Clark & Moschion, 2017, p. 2). Additionally, Douglas Downey's (1995) previous research titled "When Bigger Is Not Better: Family Size, Parental Resources, and Children's Educational Performance," found that children in larger families perform worse in math. Downey explains that in larger families, parents' economic resources are distributed among more children, resulting in fewer resources being allocated to each child. Hence, educational outcomes of each child is less in bigger families. With these findings in mind, it is important to recognize that in the Kazakh tradition, having many children is welcomed. Also important to note that a mother with four children is officially recognized as a "mother of many children" and allowances from the government are provided. For example, 55,304 Tenge per month is provided to mothers with four children with additional benefits for more children (Ministry of Labour and Social Protection of the Republic of Kazakhstan, 2019). A comprehensive investigation into the role of family size on the development of Kazakh and Russian child literacy is yet to be explored in the literature.

2.5.1.4 Family Marital Status

According to the National Statistical Bureau of the Republic of Kazakhstan (NSBRK, 2020), one-third of all families in the country are divorced, which means that thousands of children are raised in single-parent households. Several studies have investigated the correlation between a child's academic performance and the marital status of their parents. For instance, Chalachew and Lakshmi (2013) conducted a study on students from four Indian schools, examining this relationship. They obtained information about the family's marital status from the children and analyzed the child's academic achievement based on school records over a two-year period. Statistical analysis revealed that children from intact families perform better academically compared to those from divorced families. In addition, the same research study suggested that the outcomes of children from divorced and remarried families were indifferent, i.e., both less than that of children from intact families (Chalachew & Lakshmi, 2013). Another quantitative study conducted on children in elementary schools in the US revealed a negative relationship between (1) children with working mothers and those living in a single-parent household, and (2) and academic performance of a child (Milne et al. 1986). In other words, the study found that children with working mothers and those who lived in single-parent families tended to perform worse academically than their peers whose parents remained married.

The effect of single-parent families on child numeracy and literacy at the start of school, and their rate of progress in the first few years of school, is yet to be explored in Kazakhstan. Therefore, further research is needed to explore this potential relationship in the Kazakhstani context in order to measure the potential impact of such factors on children.

2.5.1.5 Parental Job Status

Parental Job Status is another factor that might affect the child's academic success at school. There are many academic investigations which explored this issue and made mixed conclusions. One of them is the article by Ariel Kalil and Patrick Wightman (2014). This study

investigates the relationship between parental job loss and children's educational attainment in the United States. The authors use data from the National Longitudinal Survey of Youth and employ a fixed-effects regression model to estimate the effect of parental job loss on children's high school graduation and college enrollment. The results show that parental job loss has a negative effect on children's high school graduation rates, but no significant effect on college enrollment rates. However, the negative effect on high school graduation is largely driven by job loss during a child's teenage years, rather than earlier in childhood. The authors suggest that job loss during the teenage years may disrupt educational plans and aspirations and lead to disengagement from school. Another study by Han, Lee, and Waldfogel (2012) aimed to investigate the school readiness of children from low-income families in the United States. The study used data from the Fragile Families and Child Wellbeing Study, which is a longitudinal study of nearly 5,000 children born in large US cities between 1998 and 2000. The study found that children from low-income families tended to have lower school readiness skills compared to children from higher-income families. Specifically, children of low-income mothers were more likely to experience lower cognitive and social-emotional readiness for school. Moreover, the study revealed that maternal job loss during a child's early years was associated with lower school readiness among children from low-income families. The authors suggest that policies to support maternal employment may benefit the school readiness of children from low-income families. The statistical data provided by CPM that is used in this thesis proposal also includes the statistical information about mother's job status and father's job status, though because of too much missing data, these data were not included in the current analysis.

2.5.1.6 Parental Involvement

Parental involvement plays a crucial role in the development of children, particularly during early elementary school, according to Kimaro and Machumu (2015). They define parental involvement as including a desire for their children's education, communication with

their children about school, establishing a structured home environment, and participating in school-related activities. However, excessive involvement in these four dimensions may harm a child's development. While most parents are willing to assist their children, many lack the necessary resources and knowledge to do so effectively.

In their article “A Longitudinal Assessment of Teacher Perceptions of Parent Involvement in Children's Education and School Performance” Izzo et al. (1999) surveyed teachers to investigate the impact of parental participation on their students' academic success. The study included an assessment of the students' academic performance and monitoring of their progress. Teachers completed a questionnaire to evaluate the quality and quantity of parental involvement. Results indicated a positive correlation between parental involvement and students' academic achievements. Moreover, parent-teacher communication can aid parents in understanding how to improve their children's education.

Another research study conducted by Hara and Burke (1998) involved a randomized controlled trial to investigate the effects of parental involvement on academic achievement. Employing a mixed-methods research design, the 175 participants were allocated to either the treatment or control group. The results of the study indicated that 48% of students in the treatment group demonstrated significant improvements in their reading literacy and vocabulary skills, as compared to those in the control group, whose parents did not partake in the parental-involvement-focussed intervention. Subsequently, the researchers posed a series of inquiries to the parents, such as the extent to which they felt welcomed by the school, the degree to which parental involvement in their children’s education could be reliably assessed, and the nature and frequency of their involvement in school activities. Notably, there remains a dearth of research examining the association between parental involvement in schools, and the effect that parental support of children’s extra-curricular activities might have, on children’s academic performance in the context of Kazakhstan.

2.5.1.7 Performing Art and Sport

There are many discussions on the impact of performing art and sport on the student's academic performance. On one hand, some parents believe that it improves student's academic attainment by enhancing some core skills such as leadership, teamwork and time management. On the other hand, it seems to take the student's a lot of time and attention. The impact of extracurricular activities on adolescent development and academic performance has been a topic of research for many years. Several articles have explored this topic from different perspectives, including the role of music, art, and sports in enhancing academic outcomes. For instance, Brown and Sax (2013) highlight the positive impact of music on cognitive and emotional development in adolescents, including improved academic performance. They argue that music can promote neural development, enhance cognitive skills, and increase motivation and engagement in academic activities. This suggests that music can be an effective tool for improving academic outcomes in adolescents. Feldman and Matjasko (2005) also support this argument and suggest that extracurricular activities can promote social, emotional, and cognitive development, and can enhance motivation and engagement in academic activities. Another study by Payne and McHugh (2018) present a meta-analysis of 57 studies showing a positive correlation between sports participation and academic achievement. They argue that sports can contribute to academic success by promoting discipline, teamwork, and time management skills, as well as by providing a sense of belonging and identity. Furthermore, Winner and Hetland's (2000) research on the impact of art education on academic achievement conclude that exposure to the arts can enhance cognitive skills and academic performance, particularly in reading, language, and math. They suggest that art education can promote critical thinking skills, creativity, and problem-solving abilities, which can translate into improved academic outcomes.

Overall, these articles suggest that extracurricular activities can play an important role in adolescent development and academic performance, by promoting cognitive, social, and emotional skills. Music, art, and sports can all be effective tools for enhancing academic outcomes, by providing motivation, engagement, and skills that are transferable to academic activities. Despite much research pointing to the benefits of performing art and sport, they also add that excessive involvement in extracurricular activities may have negative effects on mental health and well-being in some cases. Therefore, it is important to promote a balanced approach to extracurricular activities that takes into account individual needs and preferences, as well as academic demands. Nevertheless, an examination of the benefits that enrolment vs. non-enrolment in art and sport activities might have on early academic achievement may help shed light in this area. This is one of the additional focal areas of the current study.

2.5.1.8 Summary of Student-Level Factors

To sum up, research suggests that all of five of the student-level factors referred to above have an important influence on the academic achievement of a child. Specifically, child gender, experience in kindergarten, family size, parental marital status, parental involvement, and engagement in performing art and sport appear to have some role in determining early child numeracy and literacy in elementary school. Therefore, when exploring the possible differential effects of curricula reforms and LOI on child numeracy and literacy, it is also useful to explore the effect of these important student-level factors so as to understand what early childhood conditions and experiences might be advantageous to children.

2.6 School-Level Factors

Several research studies have examined how school-level factors impact students' literacy and numeracy development, but in this literature review, the focus is specifically on the school-level factors available to the author for secondary analysis in their current study (Taole, 2018; Mehisto, 2014; Tajik et al., 2021). The aim of this review is to investigate what

results could be expected in their study by exploring the role of the school language of instruction and the UCE (and how these two factors interact) in the literacy and numeracy of children in Kazakhstan. The study controls for two other school-level variables: school type (small/gymnasium/lyceum) and school rural/urban location, which are included in the available secondary data. As a result, the literature review focuses on reviewing research on how these two school-level factors impact student literacy and numeracy development, which are presented in the following three sub-sections.

2.6.1 School Rural/Urban Location

A school's rural or urban location is often associated with its infrastructure. Taole (2018) claims that schools in remote areas usually have low-quality infrastructure. In Kazakhstan, rural schools usually have older buildings, outdoor toilets, and bad roads. Taole (2018) explains that significant differences in academic performance among schools have been identified, depending on their geographic location, either in economically disadvantaged neighbourhoods in urban areas or in rural areas, in comparison to schools located in urban areas. The article by the Associate Professor at Gumilyov Eurasian National University, Nurbayev (2019) discusses the growing inequality between urban and rural schools in Kazakhstan. It highlights the lack of material and technical resources in rural schools, including interactive equipment and subject classrooms. It also mentions the relatively low qualification profile of teachers in rural schools, with fewer teachers holding the highest category. The authors note that the quality of education in small-staffed rural schools is lower than the national average and highlights the need for the state to take measures to reduce inequality. He mentions that there exist various programs aimed at improving the situation, such as the Informatization Strategy and the State Program for the Development of the Education System. However, these programs will not cover all rural schools, and more needs to be done to address the issue. In 2022, the director of Foundation for sustainable development of education in

Kazakhstan, Daniyar Toktarbay mentioned that 71% of schools in Kazakhstan were located in rural areas in 2021 (Makarova, 2022). Given that the majority of schools are located in rural areas and that the rural-urban gap in academic achievement has been an ongoing issue, the urban/rural location of a school needs to be accounted for when investigating the role of curricula reforms and school LOI on numeracy and literacy.

2.6.2 School Type (Small/Gymnasium/Lyceum)

Previous studies that have looked at student academic performance, as measured by exams such as PISA and UNT, have mostly focused on secondary school students. However, until recently, there has been a lack of large-scale standardized assessments that test the academic achievements of elementary school students. In 2015, the Ministry of Education and Science in the Republic of Kazakhstan conducted an evaluation to assess the effectiveness of implementing the UCE in elementary schools. The Center for Pedagogical Measurement (NIS) selected 17 pilot and 10 control schools to assess Kazakh language literacy and 16 pilot and 10 control schools to monitor Russian language literacy. The schools included in the study were common schools, small schools, gymnasiums, and lyceums. In the study at hand, these four control variables will be considered under school type (Courtney et al., 2022). Findings from the Courtney et al. (2022), that only focussed on single-language literacy, found that students studying Kazakh in Lyceums exhibited a statistically significantly lower rate of improvement in Kazakh literacy compared to counterparts in other schools. Therefore, it is important to account for the confounding effects of school type when estimating the effect of school reforms and language of instruction on child numeracy and literacy development.

2.6.3 School Language-of-Instruction

Finally, the language used for teaching in schools is an essential factor that affects a student's academic performance. As previously mentioned, Kazakhstan is a bilingual country where both Kazakh and Russian are official languages. According to research, Kazakhstani

parents consider the quality of education and potential future prospects when choosing the language of instruction for their children. However, despite scholars in multilingual Asian and African countries demonstrating that mother-tongue based instruction is effective for literacy development in both the mother tongue and additional languages (Courtney, 2022, p. 2), many Kazakh-speaking families prefer sending their elementary-aged children to Russian classes instead of Kazakh classes. While there is a long-lasting debate in mass media on Kazakh schools losing their popularity, little attention has been paid to investigating and increasing the quality of education in those schools. Mehisto's research (2014) reveals three reasons for the problem: a lack of learning materials in the Kazakh language, few young staff with novel ideas and teaching methods, and the rare usage of the Kazakh language in the work and private lives of people. Meanwhile, as more reforms are being drafted to improve the quality of school education in Kazakh schools, there is a need to examine, empirically, the degree to which the reforms may have functioned for each LOI to advance child numeracy and literacy in Kazakhstan.

2.7 Ecological Systems Theory

Ecological systems theory is a theoretical framework that examines the interrelationships between an individual and their environment, including the different systems that they interact with, such as the microsystem, mesosystem, exosystem, and macrosystem. The variables provided in the study can be applied to the ecological systems theory by examining how they influence the individual's development within each of these systems.

For example, the individual's age, gender, ethnicity, and family structure can be considered part of the microsystem, which includes the immediate environment where the individual directly interacts, such as family, peers, and school. The school-level variables, such as school type and language of instruction, can be considered part of the mesosystem, which involves the interactions between different microsystems, such as family and school. The

exosystem can include the community and society in which the individual resides, such as rural versus urban areas, and the macrosystem can encompass the broader cultural values, laws, and policies that influence the individual's development.

Additionally, the study's control variables, such as years of education in kindergarten, family size, marital status, mother's education level, and student's attendance of art or sport, can be considered part of the microsystem, mesosystem, and exosystem, depending on their specific influence on the individual's development.

Finally, the study's dependent variables, such as numeracy and literacy ability, can be considered as indicators of the individual's development within the different systems or ecologies. By examining the relationship between the independent and control variables with the dependent variables, the study can provide insights into how these different systems and their interactions influence the individual's development.

2.8 Summary

The literature review section provides an overview of the Kazakhstani socio-linguistic context and its trilingual aspirations, as well as a review of curricula reforms in Central Asia. The review also discusses common predictors of student academic performance in literacy and numeracy, including within- and between-school variables. Cooper's (1998) framework is used to organize and synthesize the knowledge in the literature review, which aims to critically analyze relevant research in the field and identify central issues related to numeracy and literacy outcomes of children. The literature review is organized in a clear and logical manner, and the focal audience of the review is general scholars, practitioners, and policy makers interested in how reform practices might function for indigenous and regional child language groups. The review concludes that, like Kazakhstan, other countries also experience pressures to provide child schooling using multiple language-of-instruction, and that parents' choice of LOI is often influenced by the availability of textbooks and their proficiency in the language.

The government's provision of education in different LOI is influenced by the desire to develop a cohesive national identity while integrating into the socio-economic region. Moreover, recent reform efforts by the government have been directed at improving child numeracy and literacy in both Kazakh and Russian LOI. However, it is not known whether these reform efforts have had an equal positive effect for both Kazakh and Russian speaking children. The purpose of this study is to investigate this previously unexplored area for the purpose of informing future policy and practice.

III. Methodology

3.1 Introduction

This chapter provides a summary of the methodological approach selected to address the research questions presented in the previous chapter. This chapter consists of four sections. In the first section, the research design of the study is outlined. Secondly, the sample for the analysis is specified thoroughly. In the third section, the statistical modelling approach and its rationale is presented. The last section will provide a summary of the Methodology chapter.

3.2 Research Paradigm

The current study adopts a positivist paradigm. The paradigm aims to determine and evaluate the causes, in this instance, whether or not the UCE caused improved numeracy and literacy among children in Kazakhstan. The paradigm "carefully observes and measures the objective reality" (p. 8). Cresswell (2009) claims that, positivists test or verify general truth and explain them through numeric measures. Positivists believe that truth is anti-foundational, which means it is impossible to reach an absolute truth. Therefore, specific to this belief, positivists either reject or fail to reject the hypothesis (Cresswell, 2009).

Along with paradigms, the researchers make certain philosophical assumptions before conducting the research at hand. One of them is the ontological assumption which states that there is only one reality regardless of people's perceptions. According to this epistemological assumption, the researcher attempts to remain at a distance from the research participants in order to describe their objective reality. Another type is methodological assumption, adopted by researchers who make use of this approach, is that researchers use "inductive logic, study the topic within its context, and use an emerging design" (Creswell, 2009). To sum, the nature of the research problems to be addressed in this study indicate that this paper is based on a positivist paradigm which focuses on functional relationships and patterns between independent variables and outcomes.

3.3 Research Design

In order to answer the research questions of this study, I will utilize a quantitative research design. As stated by Creswell (2014), the quantitative method is used to test objective theories by investigating the relationship between variables. Instruments can be utilized to measure the variables, and the resulting numerical data is evaluated using statistical procedures. In contrast to qualitative research, quantitative research involves testing hypotheses instead of theories. The quantitative method has the advantage of being generalizable. The inclusion of the control variables in the statistical models function to, insofar as possible, control for biases in the data (Cresswell, 2014). This research proposal employs a longitudinal quasi-experimental comparative research design which attempts to identify possible causal processes. The difference of this research from true experimental research is that the independent variable, in this instance the UCE, was not manipulated such that students were assigned at random to the UCE or traditional school curricula conditions. Nevertheless, the main advantage of the research design is that "it is possible to study both the natural history of development and impact of interventions in one research project" (Farrington et al., 2009, p. 1).

3.4 Data Collection Tools

The information utilized in this thesis is of secondary origin and was gathered as part of an earlier monitoring initiative initiated by the Kazakhstani Ministry of Science and Education. The data pertains to demographic and evaluation details of both children and schools, obtained from 19 experimental and 10 control schools as part of a monitoring program. The study monitored the numeracy and literacy skills of Kazakh- and Russian-speaking 1st grade students over a three-year period from 2015 to 2017. It's important to note that the project was under the management of the Center for Pedagogical Measurement (CPM), a research department within NIS's administrative division (IAC, 2014). In addition, it should also be noted that the test items for the first three years of the study were equivalent (due to direct

translations) between the Kazakh and Russian languages. Hence, making it possible to explore the role of both the UCE and the LOI on the development of general child numeracy and literacy for the period.

3.5 Research Sample

Participants in this study included Kazakh and Russian speaking elementary school students recorded between 2015 and 2017 under control and pilot curricula conditions. In this study, the participants were divided into two distinct groups of students with each group were evaluated according to their level of language literacy and numeracy in their Kazakh or Russian languages. All statistical data was prepared by CPM and shared with this researcher and her supervisor in spreadsheet form. All student- and school-level variables were assigned to each child based on the data collected directly for the project.

The research involved test results for a total of 756 Kazakh and 967 Russian children, with participation from 853 females and 870 males. A total 56 students attended small schools, 587 attended regular schools, 629 attended gymnasium schools, and 451 attended lyceums. Furthermore, 402 participants resided in rural areas, while 1321 lived in urban regions. Of the total participants, 144 did not attend kindergarten, 161 attended for one year, 624 for 2 years, and 794 for three years. The sample included 102 single parent households, and 1621 participants from dual-parent family structures. Additionally, 703 children's mothers had a higher education degree, while 1,020 had completed a secondary level of education. The study excluded the variable of the father's educational background due to missing data. Finally, 305 participating children had engaged in art-related activities prior to attending school, while 217 had attended extra-curricular sporting activities prior to entering school.

In addition, further descriptive statistics of the participants are provided in Tables 1 and 2.

Table 1
Demographic Characteristics of Sample Students

Group	*N*(*n*)	Sc	*N*(*n*)/ Sc	Gender (*n*)		Location (*n*)		School Type (*n*)			
				F	M	Urban	Rural	Com	Gym	Lyc	Small
Kazakh and Russian MOI Schools											
All	1723	28		853	870	1321	402	587	629	451	56

Table 2
Intra-class Correlations and Design Effects for Kazakh and Russian Literacy and Numeracy

Group (c)	2015		2016		2017	
	ICC	***de***	**ICC**	***de***	**ICC**	***de***
Literacy	.222	15.35	.344	36.87	.206	21.22
Numeracy	.168	21.22	.307	31.00	.300	19.91

Note. ICC = intra-class correlation; *de* = design effects, c = average school size; with *de* = 1 + ICC(c-1); ICC estimates calculated with the assistance of in Mplus 6.11 (Muthén & Muthén, 2011).

As the design effects were greater than 2.00, multilevel growth modelling was applied to the data.

3.6 Variables

The current study makes use of multiple independent, control, and dependent variables. A description of the variables for each of these three categories will now be provided.

3.6.1 Independent Variables

The independent variables in the current study include the school-language-of-instruction (or, medium-of-instruction) and the quasi-experimental condition, i.e., the Updated

Content of Education (UCE), as opposed to the control condition, the Traditional Curriculum. These two school-level variables were coded pilot = 2, control = 1, and Russian = 2, Kazakh = 1. In addition, an interaction term between these two variables will also be specified to explore the extent to which the UCE may have functioned to, for example, generate substantively improved growth for Russian-speaking children, as opposed to their Kazakh-speaking counterparts.

3.6.2 Control Variables

While still of research interest, the control variables in the current study include (1) child gender (female = 2, male = 1), (2) years of education in kindergarten (1 to 3 years), (3) family size or quantity of children (1 to 8 children), (4) family marital status (dual parent = 2, single parent = 1), (5) mother education level (higher education = 2, less than higher education = 1), and (6) student's attendance of art or sport (yes = 2, no = 1). Specific to each school, control variables include (1) school rural/urban location (urban = 2, rural = 1), and (2) school type (dummy coded as small, gymnasium, and lyceum, with public school as reference group). The school-level LOI (Russian/Kazakh) and intervention (Experiment/Control) interaction term was coded Russian-UCE = 1, else = 0. Appendix A provides details about the correlations between the within- and between-school independent variables used in the growth model.

3.6.3 Dependent Variables

Dependent variables in the current study include participating children's numeracy and literacy ability based on Rasch analyses of dichotomous-based student scores on three tests for 2015 to 2017. Estimates for each student for each of the three time periods were based on a link-based equating design with three common items used across adjacent test administrations. Appendix B (R Code) provides details as the how these scores were calculated. While the point estimates for student numeracy and literacy represent the outcomes of interest, because of the longitudinal nature of the data, an examination of the estimates associated initial status

(intercept) and growth rate (slope) of the ability estimates for the study period constitute the final, modelled, dependent variables in the current study. This way, the effect that the UCE and school-language-of-instruction have on (1) the initial level and (2) rate of improvement of learning can be ascertained.

There are 1,723 participants from Kazakh and Russian schools. A total, 550 of them were in a control group, while 1,171 were in a treatment group. A total 19 schools out of 27 were in a pilot group, whereas eight others were in a control group. Apart from monitoring the outcomes throughout three years in each language group, this research will also look at the relationship between the initial status (intercept) and rate of growth (slope) for within and between the respective subject groups, i.e., numeracy and literacy. It is necessary to note that, the government introduced an updated curriculum during this initial three-year period. Hence, the students in their respective school conditions were monitored for that period and interviews with parents also occurred so as to attain information about student demographic factors at the beginning of the project. Therefore, the student demographic factors are considered time invariant. All data was prepared using the open-source R language (see Appendix B for code) and multi-level growth modelling was undertaken with the assistance of the MPlus 6.11 (Muthén & Muthén, 2021) software (see Appendix C for MPlus code).

3.7 Research Methods and Procedures

The advanced quantitative techniques are required in order to analyze the factors that influence the academic outcomes of the children at the student- and school-levels. As mentioned, the multilevel modelling analysis was carried out for this project. This was done to account for the nested hierarchy of the data with student ability for the three time points nested in children, and children nested in schools (Raudenbush & Bryk, 2002). In this sense, the analysis pertains to a type of three-level growth model with the effects of the intervention and the language of instruction (and interaction term) operating at the between-school level. The

strength of using this approach is that one single model can be employed to test multiple hypotheses and the relationships between the initial statuses and growth trajectories of both subjects, i.e., the intercepts and slopes of both numeracy and literacy, can be examined so as to ascertain a thorough understanding of how children in the study developed over time.

3.8 Data Analysis

The specific data analysis approach employed in this study was multilevel parallel linear growth modelling. The numeracy and literacy outcomes of interest were generally normally distributed so general maximum likelihood estimation was deemed sufficient. Specifically, skewness for literacy was -0.19, -0.62, and -0.45, respectively for 2015, 2016, and 2017. In addition, skewness for numeracy was -0.69, -0.58, and -0.07, for the same three years. An analysis of intra-class correlation coefficients for each respective subject area and year was also undertaken as part of this research. The intraclass correlation coefficient (ICC) is a statistical measure that assesses the consistency or reliability of ratings by comparing the variation between different ratings of the same subject to the total variation observed across all participants and ratings. (Shrout, 1979). One important thing to note, ICC is dependent on the homogeneity of participants in their respective groups—in this case, schools. According to Scherbaum and Ferreter (2009), the ICC is employed to determine whether there is a significant clustering effect in the data or not. In this research proposal ICC value is used as an indicator of a substantial between-group clustering present in the data (for more details, see historic paper by Raudenbush & Bryk, 2002). In the current study, the ICC and associated design effect (de = 1 + ICC*[average cluster size – 1]) are used to first check for substantive differences in student numeracy and literacy attributable to between-school effects. Specifically, de estimates over 2.00 (Lai & Kwok, 2014) are considered substantive and therefore warranting multilevel growth modelling, as opposed to single-level growth modelling. The following subsections

provide details specific to the forms of statistical analysis applied to answer each of the research questions.

3.8.1 RQ1: Traditional- vs. UCE-Based, Numeracy and Literacy, of Kazakh- and Russian-Speaking Children

Descriptive statistics will be used to provide an understanding of RQ1. This will involve the use of means, standard deviations, and levels of skewness of all continuous (e.g., student performance) and categorical variables (e.g., school type) in the study. An examination of the extent to which the variables vary within- and between-schools (via reports of intra-class correlations, ICCs, de) will also be undertaken to determine the degree to which variables differ within- and between-schools. Estimates for the ICCs will be estimated with the assistance of the Mplus software (Muthén & Muthén, 2021).

3.8.2 RQ2: Initial Status and Growth Rate for Numeracy and Literacy

Based on the assumption of substantive levels of between-school variance in child numeracy and literacy (i.e., ICCs > .10, and de > 2.00), multilevel linear growth modelling was employed to determine the within- and between-school initial statuses and growth rates of numeracy and literacy. As part of this baseline modelling procedure, correlations between the initial status and growth rates of numeracy and literacy at both levels were also specified so as to provide insights into patterns of growth in numeracy and literacy in the data.

3.8.3 RQ3: Effect of Language-of-Instruction and Pilot UCE on Initial Status and Growth Rate of Numeracy and Literacy

Analysis for this question involved a three-phase stepwise approach. For phase one, all within- and between-school control variables will be introduced as predictors of the initial status and growth rate of child numeracy and literacy. For phase two, the independent variable, UCE, was introduced. Thereafter, for phase three, the independent variable, language-of-instruction was introduced into the model.

3.8.4 RQ4: Interaction between the (1) Pilot UCE and (2) Language-of-Instruction

For this question, the interaction term for Pilot UCE and Language-of-Instruction was modelled as a final independent variable of interest which predicts the initial status and growth rate of child numeracy and literacy at the school level. For all models, results were considered statistically significant at the $p < .05$ level.

3.9 Linked Data Structure and Reliability of Tests

Rasch analysis with a linked equating design was undertaken on the data to provide estimates of ability for the three time points (Appendix B). The standard deviations for ability (theta) and the Rasch-based reliability coefficients (rel.) were as follows.

For literacy: 2015, SD = 1.48, rel. = .78; 2016, SD = 1.12, rel. = .69; 2017, SDkz = 1.04, rel.kz = .67, and SDrs = 0.98, rel.rs = .68 (note, separate equating due to only common items administered in 2017 across Kazakh and Russian tests). For numeracy: 2015, SD = 1.17, rel. = .67; 2016, SD = 1.32, rel. = .71; 2017, *SD* = 1.07, rel. = .81.

3.10 Ethical Issues

Key ethical concepts include informed consent, voluntary participation and right to withdraw, confidentiality and anonymity, risks and safety, and benefits and reciprocity. This study does not directly involve any human participants, but uses only secondary data from CPM. However, the quantitative research makes use of the data and adheres to forms of confidentiality. Specifically, no student identifying information was shared with this author or supervisor. Therefore, there are only minimal risks associated with this research.

To answer the research questions, specialized statistical models were applied. The research included Kazakh and Russian speaking first grade students' records about their reading literacy and numeracy skills, family size, gender, years of attending kindergarten, family marital status and parental job status between 2015 and 2017 under control and pilot curricula conditions. While this information may be considered sensitive, and results pertaining

to this information, i.e., the effect of having more children on literacy and numeracy development, might be controversial, it is the opinion of the author that it is important to make this information available to the public for the purpose of generating opportunities for open discourse.

3.11 Summary

Based on the given information, the study employed advanced quantitative techniques, specifically multilevel modeling analysis, to analyze the factors that influenced the academic outcomes of children in Kazakhstan in terms of numeracy and literacy. The study utilized a positivist paradigm with a quantitative research design to test objective theories and hypotheses through statistical procedures. The data used in the study was of secondary origin and obtained from 19 experimental and 10 control schools as part of a monitoring program initiated by the Kazakhstani Ministry of Science and Education. The research sample consisted of Kazakh and Russian speaking elementary school students recorded between 2015 and 2017 under control and pilot curricula conditions, with a total of 756 Kazakh and 967 Russian children participating in the study. Overall, the study aimed to evaluate the impact of the UCE program on improving numeracy and literacy skills among children in Kazakhstan.

IV. Findings

4.1 Introduction

Results are presented for each of the research questions, in turn. The results of the research are provided in five models with some descriptions and explanations.

4.2 RQ1: Level of Numeracy and Literacy under the Traditional and UCE Conditions

The levels of numeracy and literacy for the traditional and UCE conditions for the children in the study are presented in Table 3.

Table 3

Descriptive Statistics for by Subject and Experimental Condition

Condition	2015	2016	2017
	M(*SD*)	*M*(*SD*)	*M*(*SD*)
	Literacy		
Traditional (n = 550)	0.73(1.30)	2.58(1.38)	2.82(1.07)
UCE (n = 1,168)	-0.37(1.35)	2.72(1.11)	3.12(1.07)
Total	-0.02(1.43)	2.68(1.20)	3.02(0.99)
	Numeracy		
Traditional	0.42(0.95)	1.86(1.45)	1.59(10.6)
UCE	-0.24(1.18)	1.86(1.27)	1.84(0.99)
Total	-0.03(1.16)	1.86(1.33)	1.76(1.02)

Note. UCE = updated content of education.

For the literacy subject, in the traditional condition, the mean score increased from 0.73 in 2015 to 2.58 in 2016, and then slightly increased to 2.82 in 2017. In comparison, for UCE, the mean score was -0.37 in 2015, but it increased to 2.72 in 2016 and further improved to 3.12

in 2017. Overall, the total mean score for literacy showed a slight increase from -0.02 in 2015 to 2.68 in 2016 and then to 3.02 in 2017.

For the numeracy subject, in the traditional condition, the mean score increased from 0.42 in 2015 to 1.86 in 2016 and then decreased to 1.59 in 2017. In comparison, for UCE, the mean score was -0.24 in 2015, and it remained constant at 1.86 in 2016 and 2017. The total mean score for numeracy showed a slight decrease from -0.03 in 2015 to 1.86 in 2016 and then to 1.76 in 2017.

Overall, the UCE condition resulted in higher mean scores for both numeracy and literacy subjects compared to the traditional condition over the years 2015 to 2017.

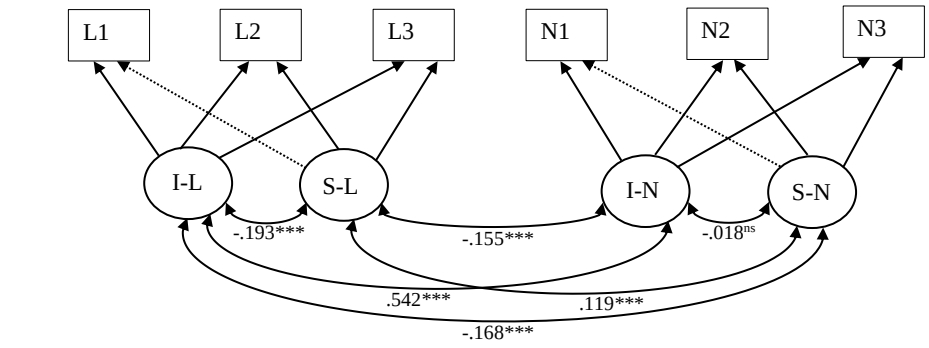
Descriptive statistics suggest that, though starting at lower levels of numeracy and literacy, the children under the UCE developed at a faster rate than counterparts learning in a traditional setting.

4.3 RQ2: Initial Status and Growth Rate of Numeracy and Literacy of the Participating Children

Figure 1 provides details as to the initial status and rate of improvement for the children in the study.

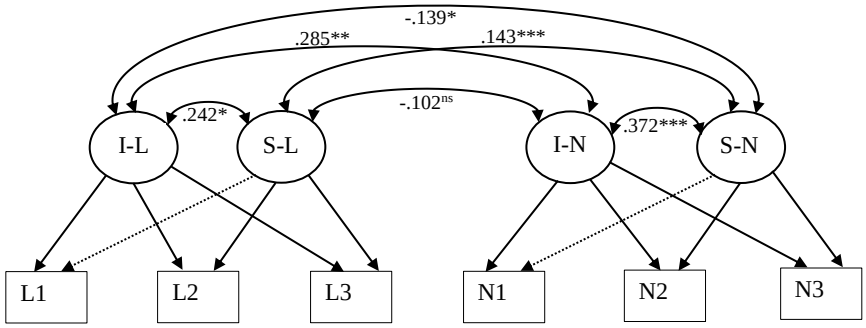
Figure 1

Baseline Multilevel Parallel Linear Growth Model for Child Numeracy and Literacy



Within-schools

Between-Schools



Note. L1-L3 = child literacy ability estimates; N1-N3 = child numeracy ability estimates; I-L = within- or between-school initial literacy status (intercept); "I" denotes respective ability initial status (intercept); "S" denotes respective growth rate (slope); 27 schools, avg. cluster = 63.63.

The baseline multilevel parallel linear growth model for child numeracy and literacy in Kazakhstan indicates the patterns of child numeracy and literacy trajectory in schools. The estimations for initial literacy and average school performance in three years reveal the negative relationship (r = .193). The estimators are similar for numeracy (r = .018). It means that, children with lower early initial literacy and numeracy tend to develop faster within and across subject areas.

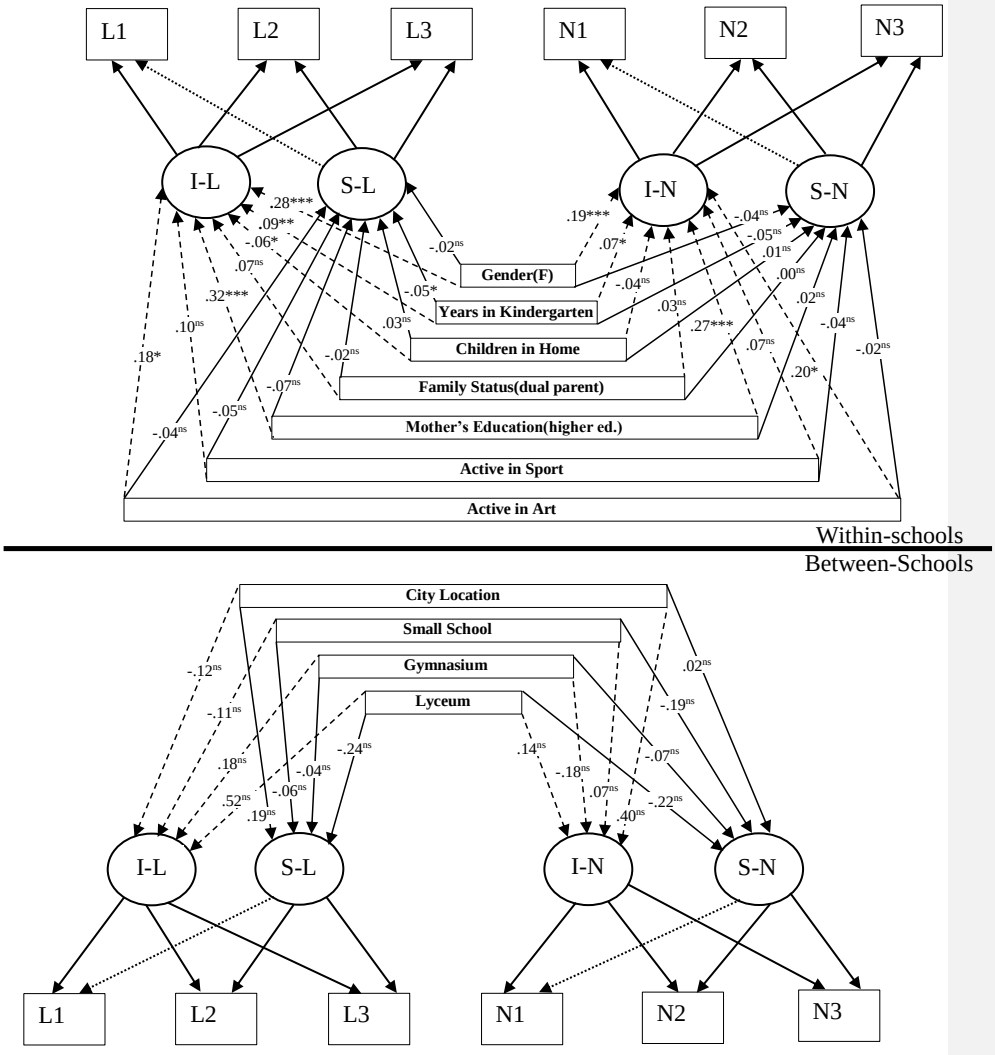
Results were to the contrary at the school level of the model. Schools with higher initial averages in literacy also tend to have higher initial averages in numeracy (r = .29, p <.001). Also, schools with higher growth rates in literacy also tend to have higher growth rates in numeracy (r = .14, p < .001). So, schools with initial high levels of literacy and numeracy tended to develop faster than schools with lower initial literacy and numeracy level. Appendix A presents the within- and between-school correlation matrices for the baseline model which illustrates very little covariance between the independent variables suggesting that the assumption of colinearity, important for regression-based analyses, was demonstrated.

4.4 RQ3: Effect of Language of Instruction and Pilot UCE on Initial Status and Growth Rates of Students in Numeracy and Literacy

Figures 2, 3, and 4 provide details as to the effect of the language of instruction and the pilot UCE on the initial status and rate of improvement for the children in the study. The results are presented in accordance with the stepwise (three model) approach as detailed in the methodology.

Figure 2

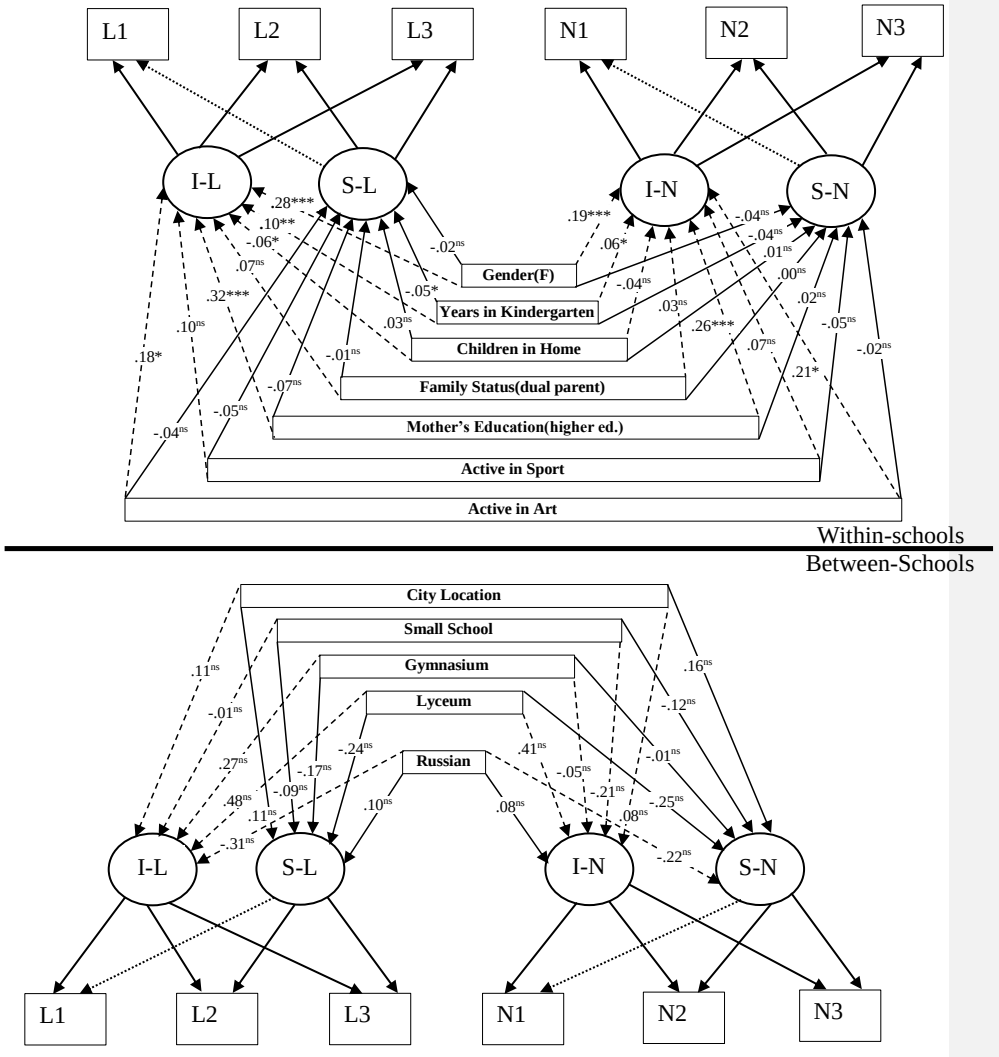
Multilevel Parallel Linear Growth Model for Child Numeracy and Literacy with Covariate Effects



Note. L1-L3 = child literacy ability estimates; N1-N3 = child numeracy ability estimates; I-L = within- or between-school initial literacy status (intercept); "I" denotes respective ability initial status (intercept); "S" denotes respective growth rate (slope); 27 schools, avg. cluster = 63.63.

Figure 3

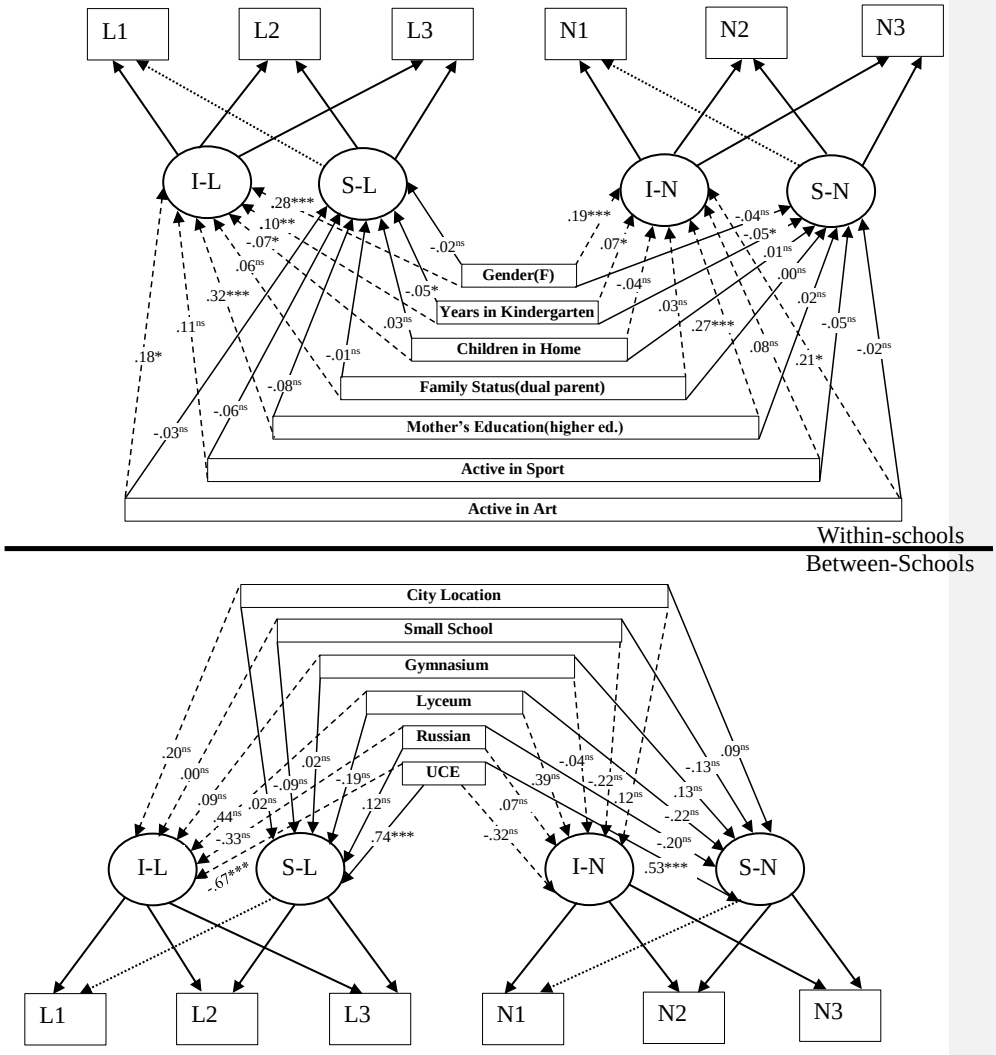
Multilevel Parallel Linear Growth Model for Child Numeracy and Literacy with Covariate and Language Effects



Note. L1-L3 = child literacy ability estimates; N1-N3 = child numeracy ability estimates; I-L = within- or between-school initial literacy status (intercept); "I" denotes respective ability initial status (intercept); "S" denotes respective growth rate (slope); 27 schools, avg. cluster = 63.63.

Figure 4

Multilevel Parallel Linear Growth Model for Child Numeracy and Literacy with Covariate, Language, and Pilot UCE Effects



Note. L1-L3 = child literacy ability estimates; N1-N3 = child numeracy ability estimates; I-L = within- or between-school initial literacy status (intercept); "I" denotes respective ability initial status (intercept); "S" denotes respective growth rate (slope); 27 schools, avg. cluster = 63.63.

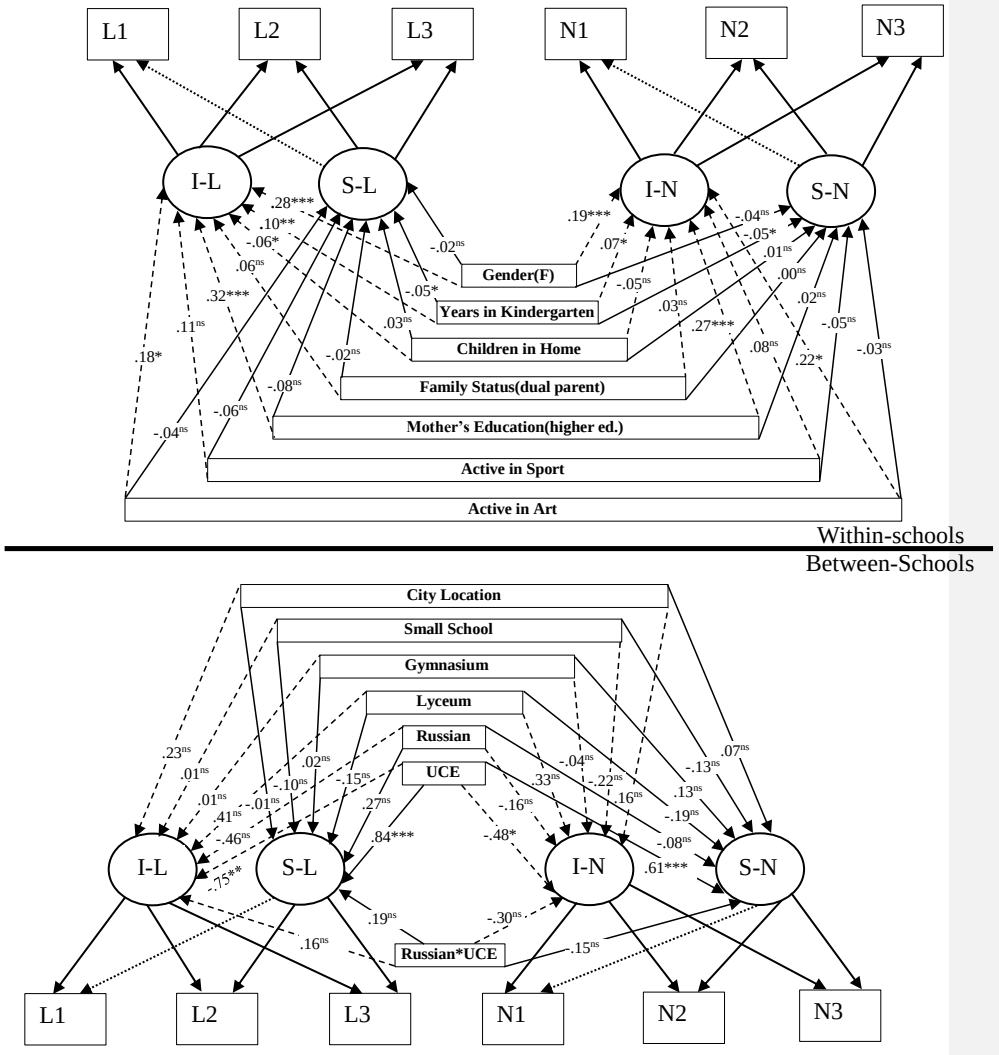
At the within-school level, results suggest that a child's status as female, more years in kindergarten, fewer children in the child's home, mother education level had a consistent statistically significant effect on the initial level of child literacy and numeracy in school. However, at the between-school level, there were no significant direct effects of school location, or school type Russian language of instruction. Importantly, the effect of the UCE had a substantive positive between-school effect on the rate of growth in numeracy and literacy in the study.

4.5 RQ4: Interaction Effect of Language of Instruction and Pilot UCE on Initial Status and Growth Rates of Students in Numeracy and Literacy

Figure 5 provides details for the results of the interaction effect between LOI (Russian) and UCE on the between-school initial status and rate of growth.

Figure 5

Multilevel Parallel Linear Growth Model for Child Numeracy and Literacy with Covariate, Language, Pilot UCE, and Language-Pilot UCE Interaction Effects



Note. L1-L3 = child literacy ability estimates; N1-N3 = child numeracy ability estimates; I-L = within- or between-school initial literacy status (intercept); "I" denotes respective ability initial status (intercept); "S" denotes respective growth rate (slope); 27 schools, avg. cluster = 63.63.

Results suggest that there are not statistically significant interaction effects between language of instruction and curricula condition.

4.7 Summary

Descriptive statistics suggested that there may have been some differences in the initial status and rate of growth between children studying under the UCE and the traditional curriculum. An analysis of the baseline model, without the inclusion of covariates, found clear patterns between the initial status and rate of growth at the within- and between-school levels.

In terms of initial literacy and numeracy skills, the within-school level provided clear evidence that students who start school with low literacy improve more than those who start at a higher rate within the same schools. In this sense, the schools in the study tended to promote better conditions for lagging students, rather than facilitating students with initially high academic performance. However, this pattern was reversed at the between-school level with average starting ability (both numeracy and literacy), resulting in faster average development. This suggested that there were some systemic differences in the capacity for some schools to develop students. While child gender (female), years of kindergarten, fewer siblings, and a child's mother's education level predicted higher numeracy at the start of school, none of the between-school factors relating to school type of location had any determination on the initial status or rate of growth of average school ability. It is noted that while the school location, school type, and language of instruction had no effect on the initial status or rate of growth between schools, the UCE had a substantive positive effect on the rate of growth for schools adopting that curricula content and approach. Finally, as the interaction effect between UCE and LOI had no substantive effects, it is concluded that the UCE functioned in a similar positive way for promoting learning in schools for both Russian and Kazakh speaking children.

V. Discussion

5.1 Discussion of the Research Findings

The study investigated the trajectories of numeracy and literacy for children in Kazakhstan from 2015 to 2017, under the traditional and UCE curricula conditions. The results suggested that UCE had a positive impact on the growth rate of both numeracy and literacy between schools. Additionally, the study found that several factors, including child gender, kindergarten experience, number of siblings, and the education level of the mother, had a statistically significant impact on a child's initial literacy and numeracy levels within schools. However, the location of the school, type of school, and language of instruction did not have a significant effect on children's initial status or rate of improvement for the study period. Moreover, schools with higher initial levels of both literacy and numeracy tended to have greater improvements in both areas compared to those schools that had lower initial levels of literacy and numeracy.

Regarding Research Question 1, the study found that both numeracy and literacy scores generally improved over time from 2015 to 2017, regardless of the curricula condition. However, the rate of growth in numeracy and literacy for schools adopting the UCE were consistently higher than those for the traditional condition, indicating the effectiveness of UCE in improving students' academic performance.

Regarding Research Question 2, the study found a positive correlation between the initial levels of literacy and numeracy and the rate of growth in numeracy and literacy at the between-school level. This suggested that schools that start with higher performing students also enjoy a particular advantage in terms of rate of improvement over other schools. Therefore, it may be important to provide additional resources and support to schools with lower initial levels of academic performance to improve the academic growth of their students.

Regarding Research Question 3, the study found that several factors, such as gender, kindergarten experience, and the education level of the mother, had a significant impact on a child's initial literacy and numeracy levels within a school. The location of the school, type of school, and language of instruction, however, did not have a significant effect on these levels. This suggests the importance of individual factors, specifically enriching pre-school experiences, for determining a child's academic ability at the beginning of school.

Regarding Research Question 4, the study found no statistically significant interaction effects between language of instruction (Russian) and curricula condition (UCE). This suggests that the UCE was equally beneficial to children in both language groups—a point that should not be lost on stakeholders. Future studies could explore the type of practice in high achievement-high growth schools (and counterpart low achievement-low growth schools) to identify what type of pedagogical and philosophical practice is employed that might be associated with such performance patterns. Overall, the current study has significant implications for the educational system in Kazakhstan and highlights the importance of ensuring that children receive enriching pre-school experiences as well as modern systematic academic support.

The “Matthew Effect” is defined as “the rich get richer, and the poor get poorer”. It should be noted that the “reverse Matthew Effect” observed within schools was only small and may be attributable to the statistical artefact called “regression to the mean”. Therefore, this pattern may not reflect real-world effects in schools. However, the between-school positive and statistically significant correlation between average school starting point and average rate of growth suggests that there are more systemic patterns of student achievement and growth present in elementary schools in Kazakhstan. Some schools could be classified as “high achievement-high growth” schools while others could be classified as “low achievement-low

growth" schools. Future research could explore this phenomenon further so as to explore why this might be.

Based on the information provided above, we can see that the assessments for both literacy and numeracy have been evaluated for their reliability using Rasch-based reliability coefficients (rel.). The reliability coefficients for literacy range from .67 to .78, while those for numeracy range from .67 to .81.

These values suggest that the assessments for both literacy and numeracy have moderate to good reliability. A reliability coefficient of .70 or higher is generally considered acceptable for educational and psychological assessments. This means that the results of the study are likely quite reliable but could also be improved in the future.

Furthermore, we can also see that the standard deviations (*SD*) for both literacy and numeracy assessments vary across different years of testing. For example, the *SD* for literacy was highest in 2015 (1.48) and lowest in 2017 (0.98), while the *SD* for numeracy was highest in 2016 (1.32) and lowest in 2017 (1.07). Generally, student performance varies more as longitudinal studies proceed. However, increased variance is often observed in longitudinal studies of adolescents, contexts in which performance is more high stakes. It may be a more natural phenomenon for younger children to exhibit similar levels of performance in early years of schooling, especially prior to more competitive high-stakes high school contexts. More research on such phenomenon might be interesting.

In addition, these variations in *SD* values across different years of testing may reflect changes in the composition of the test-taker population, changes in the test items, or other factors that may affect the reliability and validity of the assessments. Overall, the information provided suggests that the assessments for both literacy and numeracy have reasonably good reliability, but additional information would be needed to make more definitive conclusions about the quality of the assessment.

The results of this study on child numeracy and literacy trajectories in Kazakhstan have significant implications for the educational system in the country. The finding that schools with higher initial levels of literacy and numeracy tend to develop faster than schools with lower initial levels highlights the importance of providing resources and support to schools with lower initial levels of academic performance. This could include targeted interventions and programs to improve the quality of education for schools diagnosed as initially low performing.

Additionally, and importantly, the positive effect of the UCE on the rate of growth in numeracy and literacy provides evidence for the effectiveness of this curricula content and associated approaches to teaching. This suggests that schools in Kazakhstan could benefit (and, perhaps have already) from adopting the UCE to promote learning in students. This is currently the status quo today.

Furthermore, the study findings have the potential to inform other educational projects and initiatives, especially in other post-Soviet countries in the region. The use of multi-level piecewise models with four developmental stages and the stepwise approach as detailed in the methodology could be used as a framework for analyzing educational performance in other contexts that monitor student performance in general. The study also provides insight into the factors that influence initial status and rate of growth in academic performance, which could inform educational interventions (both pre- and during school) and programs in other surrounding countries facing similar economic and educational challenges.

This project provides valuable insights into the factors that influence the development of numeracy and literacy skills among children in Kazakhstan. The findings have important implications for policymakers, educators, and researchers who are interested in improving educational outcomes for children in Kazakhstan and other countries with similar contexts.

Moreover, the study's analysis of the impact of language of instruction and curricula condition on student achievement provides valuable insights into how education systems can

be structured to support student learning. The positive impact of the UCE on student achievement suggests that innovative and effective curricula can make a significant difference in student outcomes.

Overall, the findings from this project have the potential to inform educational policies and practices in Kazakhstan and other countries with similar contexts. By using data-driven insights to develop targeted interventions and curricula, educators and policymakers can work together to improve educational outcomes for all students.

5.2 Conclusion

In conclusion, the results of this study have practical implications for the educational system in Kazakhstan and provide a foundation for future research on child numeracy and literacy trajectories in other countries. By addressing the factors that influence academic performance, the educational system can better support the learning needs of all students, ultimately contributing to improved educational outcomes and opportunities for individuals and communities.

VI. Conclusions

6.1 Summary of the Major Findings

Findings from the current study suggest that mother education, the number of years a child spends in kindergarten, fewer siblings, and extra-curricula activities can be beneficial to improving early child academic performance. In terms of the major systemic-based questions, this study found that the updated curriculum had a significant positive effect on the rate of improvement in child numeracy and literacy, regardless of school type, location, language of study.

6.2 Limitations

This study has several noteworthy limitations. Firstly, the uneven size of the experimental and control groups reduces the level of confidence in the findings. Secondly, the assessment tools could have been improved by adding more items. Thirdly, this study may have overlooked a particular group of disadvantaged students and schools, resulting in an overestimation of some factors in their regression coefficients and statistical significance, thereby influencing the outcome. Fourthly, evaluating parental knowledge and job status would provide precise estimates of the distinct impacts of the pilot curriculum on child language development. Nonetheless, the study's utilization of a quantitative approach, specifically through multilevel regression analyses, makes a substantial contribution to the exploration of how revised education content impacts the literacy and numeracy development of Kazakh and Russian children. The study outcomes may be extremely advantageous for the government since it relied on a large and dependable dataset to assess the variables influencing the students' academic accomplishments.

6.3 Implications

Therefore, to improve student literacy, the Kazakhstani government should consider providing subsidies for parents to send their children to kindergarten, provide additional

financial support for families with multiple children, and provide subsidies for high quality extra-curricula activities. At a systemic level the UCE must be equally endorsed and implemented in both languages. This includes all aspects of the UCE, including modern textbooks, new assessment tools, using ICT in the classroom, switching from teacher-centered approach to student-centered approach, and so on.

6.4 Directions for Future Research

Based on the findings of the research study on The Role of the Updated Content of Education on Kazakh and Russian Child Numeracy and Literacy Development, it is recommended that the government and other policymakers should carefully consider the limitations of the study when using the results to inform policy decisions. While the study provides valuable insights into the impact of updated education content on child development, the quasi-experimental design and unequal sizes of control and treatment groups may limit the generalizability of the findings.

Overall, the findings of this study should be viewed as a valuable contribution to the research on child development and education, but should be used in conjunction with other research studies and factors to make informed policy decisions.

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Appendix A: With- and Between-School Correlation Matrices

Table A1

Within-School Correlation Matrix

variable	gen(F)	kinder	chqty	famstat	mEdu	Sport	Art
gen (F)	1	-	-	-	-	-	-
kinder	-.005^{ns}	1	-	-	-	-	-
chqty	-.031^{ns}	-.162***	1	-	-	-	-
famstat	-.012^{ns}	-.063**	.181***	1	-	-	-
mEdu	.020^{ns}	.140	-.192	.002^{ns}	1	-	-
sport	-.114***	.027^{ns}	-.116***	.014^{ns}	.119***	1	-
art	-.140***	.165***	-.154***	-.019^{ns}	.184***	-.025^{ns}	1

Table A2

Between-School Correlation Matrix

variable	city	small	gym	lyc
city	1	-	-	-
small	.101^{ns}	1	-	-
gym	-.043^{ns}	-.255^{ns}	1	-
lyc	.271^{ns}	-.199^{ns}	-.223^{ns}	1

Appendix B: R Code

```
#################################################################################################
#                                        Assel R Code                                           #
#################################################################################################
# Data Manipulation and Descriptive Statistics
# setwd("/Users/asse/Desktop/stata")
setwd("/Users/user/Desktop/Masters Students/Assel Zh")
getwd()

# Clear global environment
rm(list=ls())

# Load packages
pacman::p_load(ggplot2, car, haven, CTT, readxl, psych, lme4, misty, tidyr, bnstruct)

#################################################################################################
#                              IMPORT AND MANAGE KAZ/RUS LITERACY DATA                          #
#################################################################################################
dir()
# Russian Data
dfl.kaz <- readxl::read_xlsx("lit.kaz.2015.2017.xlsx")
dim(dfl.kaz)           # 1920
colnames(dfl.kaz)

# Kazakh Data
dfl.rus <- readxl::read_xlsx("lit.rus.2015.2017.xlsx")
dim(dfl.rus)           # 1528
colnames(dfl.rus)

# MERGE Kazakh and Russian Students (2015-2016 as these data students use the same items)
colnames(dfl.rus)[1:35]       # 2015-2016 at this stage
colnames(dfl.kaz)[1:35]       # 2015-2016 at this stage

# Bind kaz and Russian for 2015 and 2016
kaz.rus.l.2015.2016 <- rbind(dfl.kaz[, 1:35], dfl.rus[, 1:35])
kaz.rus.l.2015.2016$Language           # Kaz then Russian
dim(kaz.rus.l.2015.2016)               # 3448, 35
table(kaz.rus.l.2015.2016$Language)    # 1920 Kaz, 1528 Rus

# Improve 2015-2016 item names
colnames(kaz.rus.l.2015.2016) <- c("ID", "experiment", "Region", "School_name", "Language", "Gender", "School_type", "School_location",
                                   "OG1", "OG2.1", "OG2.2.t1", "OG2.3.t1", "OG3.t1", "OG4.1", "OG4.2", "OG5.1", "OG5.2", "OG5.3", "OG5.4",
                                   "OG2.2.t2",  "OG2.3.t2",  "OG3.t2",  "OG6",  "OG7.t1",  "OG8",  "OG9.1",  "OG9.2",  "OG9.3",  "OG9.4",  "OG10.1",
"OG10.2", "OG10.3", "OG10.4", "OG11.1.t1", "OG11.2.t1" )

################### Merge the 2017 separate Kaz/Rus Data as these have link items ##################

############################################## KAZ ###################################################
# Extract kaz lit 2017 item-response data with IDs
colnames(dfl.kaz)[1] <- "ID"
kaz.l.2017 <- dfl.kaz[, c(1, 36:47)]
dim(kaz.l.2017)
colnames(kaz.l.2017) <- c("ID", "OG11.1.kz.link", "OG11.2.kz.link", "K1.1", "K1.2", "OG7.kz.link", "K2", "K3.1", "K3.2", "K3.3", "K3.4", "K3.5",
"K3.6")

# Merge 2015-2016 dataset with the 2017kz one
```

```
kaz.ruz.l.2015.2016.2017kz <- merge(kaz.rus.l.2015.2016, kaz.l.2017, by = "ID", all.x = T)
dim(kaz.ruz.l.2015.2016.2017kz)       # 3448   47

# Order df by kaz then rus
kaz.ruz.l.2015.2016.2017kz <- kaz.ruz.l.2015.2016.2017kz[order(kaz.ruz.l.2015.2016.2017kz$Language), ]
write.csv(kaz.ruz.l.2015.2016.2017kz, "kaz.ruz.l.2015.2016.2017kz.csv")

############################################## RUS ################################################
# Extract rus lit 2017 item-response data with IDs
colnames(dfl.rus)[1] <- "ID"
rus.l.2017 <- dfl.rus[, c(1, 36:47)]
dim(rus.l.2017)
colnames(rus.l.2017) <- c("ID", "OG11.1.rs.link", "OG11.2.rs.link", "R1.1", "R1.2", "OG7.rs.link", "R2", "R3.1", "R3.2", "R3.3", "R3.4", "R3.5",
"R3.6")

# Merge 2015-2016 dataset with the 2017kz one
kaz.ruz.l.2015.2016.2017.all <- merge(kaz.ruz.l.2015.2016.2017kz, rus.l.2017, by = "ID", all.x = T)
dim(kaz.ruz.l.2015.2016.2017.all)               # 3448   47

# Order df by kaz then rus
kaz.ruz.l.2015.2016.2017.all <- kaz.ruz.l.2015.2016.2017.all[order(kaz.ruz.l.2015.2016.2017.all$Language), ]
write.csv(kaz.ruz.l.2015.2016.2017.all, "kaz.ruz.l.2015.2016.2017.all.csv")


#################################################################################################
#                          IMPORT AND MANAGE KAZ/RUS NUMERACY DATA                              #
#################################################################################################
dir()
kaz.ruz.n.2015 <- readxl::read_xlsx("data_use_math_2.0 MC+.xlsx", sheet = "1")
dim(kaz.ruz.n.2015)   # 3591
kaz.ruz.n.2016 <- readxl::read_xlsx("data_use_math_2.0 MC+.xlsx", sheet = "2")
dim(kaz.ruz.n.2016)   # 3591
kaz.ruz.n.2017 <- readxl::read_xlsx("data_use_math_2.0 MC+.xlsx", sheet = "345")
dim(kaz.ruz.n.2017)   # 3591 * note some are Uighur to be removed

# Remove Uyghur IDs
remove.uyghur.df <- readxl::read_xlsx("data_use_math_2.0 MC+.xlsx", sheet = "345")
uyghur.IDs <- remove.uyghur.df$ID[remove.uyghur.df$bklt == 5]
print(uyghur.IDs)
length(uyghur.IDs)    # 143

kaz.ruz.n.2015 <- kaz.ruz.n.2015[!kaz.ruz.n.2015$ID %in% uyghur.IDs,]
kaz.ruz.n.2016 <- kaz.ruz.n.2016[!kaz.ruz.n.2016$ID %in% uyghur.IDs,]
kaz.ruz.n.2017 <- kaz.ruz.n.2017[!kaz.ruz.n.2017$ID %in% uyghur.IDs,]

dim(kaz.ruz.n.2015)   # 3448
dim(kaz.ruz.n.2016)   # 3448
dim(kaz.ruz.n.2017)   # 3448

############################################## KAZ ################################################
# Extract kaz lit 2017 item-response data with IDs
colnames(kaz.ruz.n.2015)
dim(kaz.ruz.n.2015)                                          # 3448   16

# Remove BLKT variable
kaz.ruz.n.2015 <- kaz.ruz.n.2015[, c(2:ncol(kaz.ruz.n.2015))]
```

```
kaz.ruz.n.2016 <- kaz.ruz.n.2016[, c(2:ncol(kaz.ruz.n.2016))]
kaz.ruz.n.2017 <- kaz.ruz.n.2017[, c(2:ncol(kaz.ruz.n.2017))]

# Improve item names
colnames(kaz.ruz.n.2015) <- c("ID", "M1", "M2", "M3.1", "M3.2", "M4.t1", "M.5.1", "M5.2", "M6.1.t1", "M6.2.t1", "M7", "M8.1", "M8.2", "M9",
"M10.t1")

colnames(kaz.ruz.n.2016) <- c("ID", "M11.1", "M11.2", "M11.3", "M12.1", "M12.2", "M13.1", "M13.2",
                              "M13.3.t1", "M14.1", "M14.2", "M14.3", "M14.4.t1", "M15.1.t1", "M15.2.t1", "M15.3",
                              "M4.t2", "M6.1.t2", "M6.2.t2", "M16.1", "M17.1", "M17.2", "M17.3", "M10")

colnames(kaz.ruz.n.2017) <- c("ID", "M14.4.t2", "M18.1", "M18.2", "M19", "M20", "M21", "M22.1", "M22.2", "M22.3", "M22.4", "M22.5", "M22.6",
"M23.1", "M23.2",
                              "M13.3.t2", "M24.1", "M24.2", "M24.3", "M15.1.t2", "M15.2.t2", "M25.1", "M25.2", "M25.3")


# Perform merge for 2015-2016 on IDs
kaz.ruz.n.2015.2016 <- merge(kaz.ruz.n.2015, kaz.ruz.n.2016, by = "ID", all.x = T)
dim(kaz.ruz.n.2015.2016)                                        # 3448   38

# Perform merge for 2015-2016 and 2017 on IDs
kaz.ruz.n.2015.2016.2017.all <- merge(kaz.ruz.n.2015.2016, kaz.ruz.n.2017, by = "ID", all.x = T)
dim(kaz.ruz.n.2015.2016.2017.all)                                 # 3448   61

#############################################################################################
#                              GRAND MERGE ON KAZ/RUS LIT and NUM                           #
#############################################################################################
dim(kaz.ruz.l.2015.2016.2017.all)
dim(kaz.ruz.n.2015.2016.2017.all)

kaz.ruz.l.n.2015.2016.2017.all <- merge(kaz.ruz.l.2015.2016.2017.all, kaz.ruz.n.2015.2016.2017.all, by = "ID", all.x = T)
dim(kaz.ruz.l.n.2015.2016.2017.all)

kaz.ruz.l.n.2015.2016.2017.all <- kaz.ruz.l.n.2015.2016.2017.all[order(kaz.ruz.l.n.2015.2016.2017.all$Language), ]

head(kaz.ruz.l.n.2015.2016.2017.all)
write.csv(kaz.ruz.l.n.2015.2016.2017.all, "kaz.ruz.l.n.2015.2016.2017.all.csv")


#############################################################################################
#                                    GRAND MERGE WITH DEMOGRAOHIC INFO                      #
#############################################################################################

########################## Check Duplicates of Kaz and Rus Students ##################################
length(kaz.ruz.l.n.2015.2016.2017.all$ID)
length(unique(kaz.ruz.l.n.2015.2016.2017.all$ID))  # 3448 unique IDs

#################################### Download Tech Map  ######################################
dir()
tech.map <- readxl::read_xlsx("texhnological_map.xlsx")
dim(tech.map)    # 4924   11     * this is all students so not all relevant

################################## Check Duplicates in Tech Map ##################################
length(tech.map$id)          # 4924
length(unique(tech.map$id))   # 4914
```

```
# Remove the duplicates from tech map
tech.map <- tech.map[!duplicated(tech.map$id), ]
dim(tech.map)   # 4914   11

################################ Only Include Kaz-Rus Students in Tech Map ##########################
# 3448 total kaz-rus students, 4914 total in tech map
dim(kaz.ruz.l.n.2015.2016.2017.all)    # 3448   35
dim(tech.map)                          # 4914   11

sum(tech.map$id %in% kaz.ruz.l.n.2015.2016.2017.all$ID)  # 3438/3448, so ten students from kaz.rus.2015.2016 are not in tech map
#* we need to remove those students from kaz.rus.2015.2016

################### Remove Ten Students From Kaz-Rus Data That Are Not in Tech Map #################
dim(kaz.ruz.l.n.2015.2016.2017.all) # 3448
kaz.ruz.l.n.2015.2016.2017.all <- kaz.ruz.l.n.2015.2016.2017.all[kaz.ruz.l.n.2015.2016.2017.all$ID %in%  tech.map$id, ]
dim(kaz.ruz.l.n.2015.2016.2017.all) # 3438  119

sum(kaz.ruz.l.n.2015.2016.2017.all$ID %in% tech.map$id)  # 3438

################################ Merge Kaz-Rus Data with Tech Map Data  ############################
# Merge the tech data
colnames(tech.map)[1] <- "ID"
dim(kaz.ruz.l.n.2015.2016.2017.all)    # 3438   119
dim(tech.map)                          # 4914   11

tech.map$ID

kaz.ruz.l.n.2015.2016.2017.all <- merge(kaz.ruz.l.n.2015.2016.2017.all, tech.map, by = "ID", all.x = T)
dim(kaz.ruz.l.n.2015.2016.2017.all) # 3438   129

head(kaz.ruz.l.n.2015.2016.2017.all)

# All data is merged

#############################################################################################################
#                                              DATA PREP                                                    #
#############################################################################################################
# Recode variable to numeric as necessary

# School variables
df <- kaz.ruz.l.n.2015.2016.2017.all

dim(df)  # 129

table(df$experiment)
df$experiment <- car::recode(df$experiment, "'pilot' = 2; 'control' = 1")
table(df$experiment)

table(df$School_name)
df$School_name[1:10]
df$School_name <- as.numeric(as.factor(df$School_name))
df$School_name[1:10]

table(df$Language)
df$Language <- car::recode(df$Language, "'kazakh' = 1; 'russian' = 2")
```

```
table(df$Gender)
df$Gender <- car::recode(df$Gender, "'female' = 2; 'male' = 1")
table(df$Gender)
which(colnames(df) == "Gender")
colnames(df)[6] <- "GenderF2"

table(df$School_type)
df$School_type <- car::recode(df$School_type, "'МКШ' = 1; 'СШ' = 2; 'ШГ' = 3; 'ШЛ' = 4")
# dummies
small.sch <- car::recode(df$School_type, "1 = 1; else = 0")
gym.sch <- car::recode(df$School_type, "3 = 1; else = 0")
lyc.sch <- car::recode(df$School_type, "4 = 1; else = 0")
df <- cbind.data.frame(df, small.sch, gym.sch, lyc.sch)
colnames(df)

table(df$School_location)
df$School_location <- car::recode(df$School_location, "'urban' = 2; 'city' = 2; 'rural' = 1")
colnames(df)[8] <- c("City_2")

# Demographic variable
table(df$kindergarten)
df$kindergarten <- car::recode(df$kindergarten, "'didn't attend' = 0; 'less than 1 year' = 1; '1-2 years' = 2; 'more than 2 years' = 3;
                                          'attended' = 1; 'pre-school' =  1")

table(df$children_qty)

table(df$child_order)
sum(is.na(df$child_order))            # too numerous so omit
which(colnames(df) == "child_order")  # 122
df <- df[,-122]

table(df$family_status)
df$family_status <- car::recode(df$family_status, "'single parent, many children' = 1; 'single-parent' = 1;  'single-parent, low income' = 1; else
= 2")
table(df$family_status)

table(df$m_edu)
df$m_edu <- car::recode(df$m_edu, " 'higher'  = 2; 'secondary scpecial' = 1; 'secondary' =  1")
table(df$m_edu)

table(df$f_edu)                       # higher ed omitted so remove
sum(is.na(df$f_edu))                  # 1751
which(colnames(df) == "f_edu")        # 124
df <- df[,-124]

table(df$m_company)                   # Too numerous so omit
sum(is.na(df$m_company))              # 1
which(colnames(df) == "m_company")    # 124
df <- df[,-124]

table(df$f_company)                   # Too numerous so omit
sum(is.na(df$f_company))              # 282
which(colnames(df) == "f_company")    # 124
df <- df[,-124]

table(df$sport)                       # Include as useful variable as binary
```

```
sum(is.na(df$sport))                # 3118
df$sport <- car::recode(df$sport, "NA = 0; else = 1")

table(df$art)                       # Include as useful variable
sum(is.na(df$art))                  # 3030
df$art <- car::recode(df$art, "NA = 0; else = 1")

dim(df)    # 3438 125
colnames(df)

# Order by Kaz Rus
df <- df[order(df$Language), ]

table(df$Language)
df[1:40, ]
df[1900:1950, ]


#########################################################################################################
#################################### Modelling for Literacy #############################################
#########################################################################################################

################### 2015: OG1 to OG5.4 ##################################################################
colnames(df)
head(df)[,9:19]
df[, 9:19]

mod.l.t1 <- TAM::tam.mml(df[, 9:19], constraint = "cases")
sd(mod.l.t1$person$EAP)
mod.l.t1$EAP.rel #

dim(df)
t1.l <- mod.l.t1$person$EAP
df <- cbind.data.frame(df, t1.l)
dim(df)

mod.l.t1$item      # link items are:
# OG2.2.t1           -1.5682797
# OG2.3.t1            0.1600640
# OG3.t1              0.7234619

colnames(df)

################### 2015 link with 2016 ##################################################################
colnames(df)[20:35]
colnames(df)[20:35]  # positions are 1, 2, 3

# Get link item information from 2015 test for 2016 test:
colnames(df)[20:35]                                     # Colnames in 2016 test
names.in.2016 <- c("OG2.2.t2", "OG2.3.t2", "OG3.t2")    # saved names for 2016
xsi.item <- mod.l.t1$item$xsi.item[3:5]                 # item difficulty estimates from 2015
item <- c(1,2,3)                                        # item positions in 2016
link.df <-cbind.data.frame(item, xsi.item)
rownames(link.df) <- names.in.2016
print(link.df)                                          # To be placed in subsequent TAM algorithm
```

```
mod.l.t2 <- TAM::tam.mml(df[, 20:35],
                         xsi.fixed = link.df)

sd(mod.l.t2$person$EAP)
mod.l.t2$EAP.rel #

dim(df)
t2.l <- mod.l.t2$person$EAP
df <- cbind.data.frame(df, t2.l)
dim(df)              #     # 3438 128
colnames(df)

################### 2016 link with 2017kz ###############################################################

# Get link item information from 2016 main test for 2017kz test:
colnames(df)[36:47]                                                    # Colnames in 2017 Kazakh test
names.in.2017 <- c("OG11.1.kz.link", "OG11.2.kz.link", "OG7.kz.link")  # saved names for 2017
xsi.item <- mod.l.t2$item$xsi.item[c(5, 15, 16)]                       # item difficulty estimates from 2016

mod.l.t2$item      # link items are:
# OG7.t1            0.95805177
# OG11.1.t1         0.93561845
# OG11.2.t1         1.51278812

which(colnames(df) %in% c("OG11.1.kz.link", "OG11.2.kz.link", "OG7.kz.link"))  # 36, 37, 40, but 1, 2, 5 when subset

item <- c(1,2,5)                                                       # item positions in 2017 test
link.df <-cbind.data.frame(item, xsi.item)
rownames(link.df) <- names.in.2017
print(link.df)                                                         # To be placed in subsequent TAM algorithm

table(df$Language)                                                     # 1:1912 are KZ
mod.l.t3kz <- TAM::tam.mml(df[1:1912, 36:47],
                           xsi.fixed = link.df)

sd(mod.l.t3kz$person$EAP)
mod.l.t3kz$EAP.rel #

dim(df)
t3.l.kz <- mod.l.t3kz$person$EAP
length(t3.l.kz)                      # 1912 literacy ability estimates for kz students
table(df$Language)


df <- cbind.data.frame(df, c(t3.l.kz, rep(NA, 1526)))
dim(df)              #     # 3438 128
colnames(df)
colnames(df)[131] <- "t3.l.kz"



################### 2016 link with 2017rs ###############################################################

# Get link item information from 2016 main test for 2017kz test:
colnames(df)[48:59]                                                    # Colnames in 2017 Kazakh test
names.in.2017 <- c("OG11.1.rs.link", "OG11.2.rs.link", "OG7.rs.link")  # saved names for 2017
```

```
xsi.item <- mod.l.t2$item$xsi.item[c(5, 15, 16)]                              # item difficulty estimates from 2016

mod.l.t2$item      # link items are:
# OG7.t1            0.95805177
# OG11.1.t1         0.93561845
# OG11.2.t1         1.51278812

which(colnames(df) %in% c("OG11.1.rs.link", "OG11.2.rs.link", "OG7.rs.link"))  # 48, 49, 52, but 1, 2, 5 when subset

item <- c(1,2,5)                                                              # item positions in 2017 test
link.df <-cbind.data.frame(item, xsi.item)
rownames(link.df) <- names.in.2017
print(link.df)                                                                # To be placed in subsequent TAM algorithm

table(df$Language)                                                            # 1:1912 are KZ
mod.l.t3rs <- TAM::tam.mml(df[1913:nrow(df), 48:59],
                           xsi.fixed = link.df)

sd(mod.l.t3rs$person$EAP)
mod.l.t3rs$EAP.rel #

dim(df)
t3.l.rs <- mod.l.t3rs$person$EAP
length(t3.l.rs)                                                               # 1526 literacy ability estimates for rs students
table(df$Language)

df <- cbind.data.frame(df, c(rep(NA, 1912), t3.l.rs))
dim(df)                    # 3438 130
colnames(df)[132] <- "t3.l.rs"

df$Language
head(df)  # kaz = 1, rus = 2
df$t3.l.kz[1:1912]
df$t3.l.rs[1913:nrow(df)]

t3.l <- c(df$t3.l.kz[1:1912], df$t3.l.rs[1913:nrow(df)])

df <- cbind.data.frame(df, t3.l)
dim(df)                    # 3438  133

#############################################################################################


#############################################################################################
################################### Modelling for Numeracy ##################################
#############################################################################################

################### 2015: M1 to M10 ###########################################################
colnames(df)
head(df)[,60:73]
df[, 60:73]

mod.n.t1 <- TAM::tam.mml(df[, 60:73], constraint = "cases")

sd(mod.n.t1$person$EAP)
mod.n.t1$EAP.rel #
```

```
dim(df)
t1.n <- mod.n.t1$person$EAP
df <- cbind.data.frame(df, t1.n)
dim(df)

mod.n.t1$item[c(5,8,9,14), c(1, 4)]

#            item   xsi.item
# M4.t1     M4.t1 -1.3824199
# M6.1.t1 M6.1.t1 -1.9141673
# M6.2.t1 M6.2.t1 -2.5850178
# M10.t1   M10.t1 -0.8635241

################### 2015 link with 2016 ###################################################################
colnames(df)[74:96]
colnames(df)[74:96]  # positions are 16, 17, 18, 23

# Get link item information from 2015 test for 2016 test:
colnames(df)[74:96]                                                  # Colnames in 2016 test
names.in.2016 <- c("M4.t2", "M6.1.t2", "M6.2.t2", "M10")             # saved names for 2016
xsi.item <- mod.n.t1$item$xsi.item[c(5,8,9,14)]                      # item difficulty estimates from 2015
item <- c(16, 17, 18, 23)                                            # item positions in 2016
link.df <-cbind.data.frame(item, xsi.item)
rownames(link.df) <- names.in.2016
print(link.df)                                                 # To be placed in subsequent TAM algorithm

mod.n.t2 <- TAM::tam.mml(df[, 74:96],
                         xsi.fixed = link.df)

sd(mod.n.t2$person$EAP)
mod.n.t2$EAP.rel #

dim(df)
t2.n <- mod.n.t2$person$EAP
df <- cbind.data.frame(df, t2.n)
dim(df)                   # 3438 135

################### 2016 link with 2017 ###################################################################
colnames(df)[97:119]
colnames(df)[97:119]         # positions are 1, 15, 19, 20

# Get link item information from 2015 test for 2016 test:
colnames(df)[97:119]                                                  # Colnames in 2017 test
names.in.2016 <- c("M14.4.t2", "M13.3.t2", "M15.1.t2", "M15.2.t2")    # saved names for 2016
xsi.item <- mod.n.t2$item$xsi.item[c(12, 8, 13, 14)]                      # item difficulty estimates from 2016, note order for first two
reversed in 2017 matrix
item <- c(1, 15, 19, 20)                                              # item positions in 2016
link.df <-cbind.data.frame(item, xsi.item)
rownames(link.df) <- names.in.2016
print(link.df)                                                 # To be placed in subsequent TAM algorithm

mod.n.t3 <- TAM::tam.mml(df[, 97:119],
                         xsi.fixed = link.df)

sd(mod.n.t3$person$EAP)
```

```
mod.n.t3$EAP.rel #

dim(df)
t3.n <- mod.n.t3$person$EAP
df <- cbind.data.frame(df, t3.n)
dim(df)                    # 3438 136

#############################################################################################
######################################## Missing Data Analysis ##############################
#############################################################################################

sort(apply(df, 2, FUN = function(x)sum(is.na(x))), decreasing = T)

# m_edu:          24 missing
# children_qty:   21 missing

head(df)
col.2.imp  <-  which(colnames(df)  %in%    c("School_name",  "Language",  "School_type",  "School_location",  "kindergarten",  "children_qty",
"family_status", "m_edu", "sport", "art"))

df.to.imp <- df[,col.2.imp]
df.to.imp <- as.matrix(df.to.imp)
df.imp <- bnstruct::knn.impute(df.to.imp, k = 5)
apply(df.imp, 2, FUN = function(x)sum(is.na(x)))
df[,col.2.imp] <- df.imp
sort(apply(df, 2, FUN = function(x)sum(is.na(x))), decreasing = T)
# Imputation done

#############################################################################################
################################## Examine Between-School Variance ##########################
#############################################################################################

head(df)
# Assumption of no within-school variance for between-school variables

############################################ Experiment #####################################
tapply(df$experiment, df$School_name, FUN = function(x)sd(x))              # experiment!

########################################### Test Language ###################################
length(unique(df$School_name))                                             # 43 unique schools
tapply(df$Language, df$School_name, FUN = function(x)sd(x))
sum(!tapply(df$Language, df$School_name, FUN = function(x)sd(x)) == 0)     # 15/43 schools have children tested in multiple languages
schools.to.omit <- which(!tapply(df$Language, df$School_name, FUN = function(x)sd(x)) == 0)
dim(df)
df <- df[!df$School_name %in% schools.to.omit, ]
dim(df)
length(unique(df$School_name))                                             # 28 unique schools

tapply(df$Language, df$School_name, FUN = function(x)sd(x))
table(df$experiment)                                                       # 550 control (1), 1171 pilot students (2)
length(unique(df$School_name[df$experiment == 1]))                         # 8 control schools
length(unique(df$School_name[df$experiment == 2]))                         # 20 pilot schools

############################################ School Type ####################################
table(df$School_type)
tapply(df$School_type, df$School_name, FUN = function(x)sd(x))    # no problem
```

```
table(df$small.sch)
tapply(df$small.sch, df$experiment, FUN = function(x)sd(x))       # no problem
table(df$experiment[df$small.sch == 1])
table(df$experiment[df$small.sch == 0])

table(df$gym.sch)
tapply(df$gym.sch, df$experiment, FUN = function(x)sd(x))       # no problem
table(df$experiment[df$gym.sch == 1])
table(df$experiment[df$gym.sch == 0])

table(df$lyc.sch)
tapply(df$lyc.sch, df$experiment, FUN = function(x)sd(x))       # no problem
table(df$experiment[df$lyc.sch == 1])
table(df$experiment[df$lyc.sch == 0])

############################################## small school ########################################
table(df$School_type)
tapply(df$School_type, df$School_name, FUN = function(x)sd(x))    # no problem

########################################### School Location ########################################
tapply(df$City_2, df$School_name, FUN = function(x)sd(x))    # no problem

############################################## School Type #########################################
tapply(df$School_type, df$School_name, FUN = function(x)sd(x))    # no problem

# DONE!

#################################################################################################
################################### Examine Within-School Variance ##############################
#################################################################################################

############################################### Gender ##########################################
tapply(df$GenderF2, df$School_name, FUN = function(x)sd(x))                  # gender OK!

############################################### Kinder ##########################################
tapply(df$kindergarten, df$School_name, FUN = function(x)sd(x))              # ***kinder major problem

########################################### children_qty #########################################
tapply(df$children_qty, df$School_name, FUN = function(x)sd(x))              # OK

########################################### family_status ########################################
tapply(df$family_status, df$School_name, FUN = function(x)sd(x))             # ***problem

############################################### m_edu ###########################################
tapply(df$m_edu, df$School_name, FUN = function(x)sd(x))                     # *problem with school 8 only
dim(df)                                                                      # 1721, 130
df <- df[!df$School_name == 8, ]
dim(df)                                                                      # 1718, 130

############################################### sport ###########################################
tapply(df$sport, df$School_name, FUN = function(x)sd(x))                     # ***problem

################################################ art ############################################
tapply(df$art, df$School_name, FUN = function(x)sd(x))                       # ***problem
```

```
# END

#############################################################################################
########################## Group Mean Centering of Within-Group Variables ##########################
#############################################################################################

# GenderF2, children_qty, and m_edu

############################################ GenderF2 ############################################
tapply(df$GenderF2, df$School_name, FUN = function(x)sd(x))          # leave as binary

########################################### children_qty ###########################################
# Order first!
df <- df[order(df$School_name), ]

table(df$children_qty)

resp.child.qtty.means <- tapply(df$children_qty, df$School_name, FUN = function(x)mean(x))           # Extract respective child means for each
school
print(resp.child.qtty.means)


resp.child.n.4.schools <- table(df$School_name)                                                    # Extract respective frequency of students in
each school
print(resp.child.n.4.schools)

children_qty_sch_mean <- rep(resp.child.qtty.means, resp.child.n.4.schools)                         # rep means by frequency for new mean vector
print(children_qty_sch_mean)
length(children_qty_sch_mean)                                                                      # 1718

children_qty_grp_m_ctr <- df$children_qty - children_qty_sch_mean                                   # Generate group mean centered variable

tapply(children_qty_grp_m_ctr, df$School_name, FUN = function(x)mean(x))                           # Done!

ch_qty_ctr <- children_qty_grp_m_ctr
df <- cbind.data.frame(df, ch_qty_ctr)

########################################### m_edu ##########################################################

table(df$m_edu)                                                    # leave as binary!
head(df)
write.csv(df, "data.for.assel.csv")

df$experiment <- car::recode(df$experiment, "2=1;1=0")
table(df$experiment)
df$Language <- car::recode(df$Language, "2=1;1=0")
table(df$Language)

# Code Russian x Experiment Interaction
rus.exp <- df$Language*df$experiment
table(rus.exp)                              # 662
df <- cbind.data.frame(df, rus.exp)
colnames(df)
write.csv(df, "model5.csv")

# Code Russian x Control Interaction
```

```
control.grp <- car::recode(df$experiment, "1 = 0; 0 = 1")     # reverse it
rus.con <- control.grp * df$Language
table(rus.con)                                  # 304

# Code Kazakh x Experiment Interaction
kaz.grp <- car::recode(df$Language, "1 = 0; 0 = 1")
kaz.exp <- kaz.grp*df$experiment
table(kaz.exp)                                  # 506

# Code Kazakh x Control Interaction
kaz.con <- kaz.grp*control.grp
table(kaz.con)                                  # 246

nrow(df) == 662+304+506+246
colnames(df)
df <- cbind.data.frame(df, rus.con, kaz.exp, kaz.con)
colnames(df)
write.csv(df, "model6.csv")

#############################################################################################

length(table(df$School_name))
tapply(df$School_name, df$experiment, FUN = function(x)table(x))

# Some descriptives
psych::skew(df$t1.l)
psych::skew(df$t2.l)
psych::skew(df$t3.l)

psych::skew(df$t1.n)
psych::skew(df$t2.n)
psych::skew(df$t3.n)

#############################################################################################
# Levels of numeracy and literacy
# overall lit
describe(df$t1.l)
describe(df$t2.l)
describe(df$t3.l)

describe(df$t1.n)
describe(df$t2.n)
describe(df$t3.n)

# traditional and exp lit
table(df$experiment)
describe(df$t1.l[df$experiment == 1])
describe(df$t1.l[df$experiment == 0])

describe(df$t2.l[df$experiment == 1])
describe(df$t2.l[df$experiment == 0])

describe(df$t3.l[df$experiment == 1])
describe(df$t3.l[df$experiment == 0])

# overall lit
```

```
describe(df$t1.l)
describe(df$t2.l)
describe(df$t3.l)

describe(df$t1.n)
describe(df$t2.n)
describe(df$t3.n)

# traditional and exp num
describe(df$t1.n[df$experiment == 1])
describe(df$t1.n[df$experiment == 0])

describe(df$t2.n[df$experiment == 1])
describe(df$t2.n[df$experiment == 0])

describe(df$t3.n[df$experiment == 1])
describe(df$t3.n[df$experiment == 0])
```

Appendix C: MPlus Code

MODEL 1 (null model) *just model with t1.l , t2.l, t3.l , t1.n, t2.n, t3.n
Between Group
none
Within Group
None

```
Title:
Kaz_2015_to_2017_MLM_Growth no covariates;

Data:
File is Z:\baseline.parallel.csv;
! C:\Users\ICTStudent\Desktop\Analysis\uyghur_growth.df.csv;

Variable:
Names are school t1l t2l t3l t1n t2n t3n;

Usevar are t1l t2l t3l t1n t2n t3n;
!Usevar are t1n t2n t3n;

cluster = school;

ANALYSIS:
TYPE = TWOLEVEL;
ESTIMATOR = ML;

MODEL:
%WITHIN%
iw1 sw1 | t1l@0 t2l@1 t3l@2;
t1l(1); t2l(1); t3l(1);

iw2 sw2 | t1n@0 t2n@1 t3n@2;
t1n(1); t2n(1); t3n(1);

%BETWEEN%
ib1 sb1 | t1l@0 t2l@1 t3l@2;
t1l(0); t2l(0); t3l(0);

ib2 sb2 | t1n@0 t2n@1 t3n@2;
t1n(0); t2n(0); t3n(0);


OUTPUT: STDYX;
```

MODEL 2 (basic predictor model)

```
Between Group
small.sch
gym.sch
lyc.sch
City_2,
Within Group
GenderF2
children_qty
m_edu

Title:
Kaz_2015_to_2017_MLM_Growth with covariates;

Data:
File is Z:\model2.csv;
! C:\Users\ICTStudent\Desktop\Analysis\uyghur_growth.df.csv;

Variable:
Names are school genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n;

Usevar are school genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n;

cluster = school;

within = genf2 kind chqty famstat medu sport art;

between = city2 small gym lyc;

ANALYSIS:
TYPE = TWOLEVEL;
ESTIMATOR = ML;

MODEL:
%WITHIN%
iw1 sw1 | t1l@0 t2l@1 t3l@2;
t1l(1); t2l(1); t3l(1);

iw1 ON genf2 kind chqty famstat medu sport art;
sw1 ON genf2 kind chqty famstat medu sport art;

iw2 sw2 | t1n@0 t2n@1 t3n@2;
t1n(1); t2n(1); t3n(1);

iw2 ON genf2 kind chqty famstat medu sport art;
sw2 ON genf2 kind chqty famstat medu sport art;

%BETWEEN%
```

```
ib1 sb1 | t1l@0 t2l@1 t3l@2;
t1l(0); t2l(0); t3l(0);

ib1 ON city2 small gym lyc;
sb1 ON city2 small gym lyc;

ib2 sb2 | t1n@0 t2n@1 t3n@2;
t1n(0); t2n(0); t3n(0);

ib2 ON city2 small gym lyc;
sb2 ON city2 small gym lyc;

OUTPUT: TECH1 TECH8 STDYX;
```

Model 2a: (predictor variables)

```
Kaz_2015_to_2017_MLM_Growth with covariates;

Data:
File is Z:\model2.csv;
! C:\Users\ICTStudent\Desktop\Analysis\uyghur_growth.df.csv;

Variable:
Names are school genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n;

Usevar are school genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n;

cluster = school;

within = genf2 kind chqty famstat medu sport art;

between = city2 small gym lyc;

ANALYSIS:
TYPE = TWOLEVEL;
ESTIMATOR = ML;

MODEL:
%WITHIN%
iw1 sw1 | t1l@0 t2l@1 t3l@2;
t1l(1); t2l(1); t3l(1);

iw1 ON genf2 kind chqty famstat medu sport art;
sw1 ON genf2 kind chqty famstat medu sport art;

iw2 sw2 | t1n@0 t2n@1 t3n@2;
t1n(1); t2n(1); t3n(1);
```

```
iw2 ON genf2 kind chqty famstat medu sport art;
sw2 ON genf2 kind chqty famstat medu sport art;

genf2 WITH kind chqty famstat medu sport art;
kind WITH chqty famstat medu sport art;
chqty WITH famstat medu sport art;
famstat WITH medu sport art;
medu WITH sport art;
sport WITH art;

%BETWEEN%
ib1 sb1 | t1l@0 t2l@1 t3l@2;
t1l(0); t2l(0); t3l(0);

ib1 ON city2 small gym lyc;
sb1 ON city2 small gym lyc;

ib2 sb2 | t1n@0 t2n@1 t3n@2;
t1n(0); t2n(0); t3n(0);

ib2 ON city2 small gym lyc;
sb2 ON city2 small gym lyc;

city2 WITH small gym lyc;
small WITH gym lyc;
gym WITH lyc;

OUTPUT: TECH1 TECH8 STDYX;
```

MODEL 3 (basic predictor model + language)
Between Group
Within Group

```
Title:
Kaz_2015_to_2017_MLM_Growth with covariates;

Data:
File is Z:\model3.csv;
! C:\Users\ICTStudent\Desktop\Analysis\uyghur_growth.df.csv;

Variable:
Names are school lang genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n;

Usevar are school lang genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n;
```

```
cluster = school;

within = genf2 kind chqty famstat medu sport art;

between = lang city2 small gym lyc;

ANALYSIS:
TYPE = TWOLEVEL;
ESTIMATOR = ML;

MODEL:
%WITHIN%
iw1 sw1 | t1l@0 t2l@1 t3l@2;
t1l(1); t2l(1); t3l(1);

iw1 ON genf2 kind chqty famstat medu sport art;
sw1 ON genf2 kind chqty famstat medu sport art;

iw2 sw2 | t1n@0 t2n@1 t3n@2;
t1n(1); t2n(1); t3n(1);

iw2 ON genf2 kind chqty famstat medu sport art;
sw2 ON genf2 kind chqty famstat medu sport art;

%BETWEEN%
ib1 sb1 | t1l@0 t2l@1 t3l@2;
t1l(0); t2l(0); t3l(0);

ib1 ON city2 lang small gym lyc;
sb1 ON city2 lang small gym lyc;

ib2 sb2 | t1n@0 t2n@1 t3n@2;
t1n(0); t2n(0); t3n(0);

ib2 ON city2 lang small gym lyc;
sb2 ON city2 lang small gym lyc;

OUTPUT: TECH1 TECH8 STDYX;
```

MODEL 4 (basic predictor model + language + experiment)
Between Group
Within Group

```
Title:
Kaz_2015_to_2017_MLM_Growth with covariates;

Data:
File is Z:\model4.csv;
! C:\Users\ICTStudent\Desktop\Analysis\uyghur_growth.df.csv;
```

```
Variable:
Names are uce school lang genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n;

Usevar are uce school lang genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n;

cluster = school;

within = genf2 kind chqty famstat medu sport art;

between = uce lang city2 small gym lyc;

ANALYSIS:
TYPE = TWOLEVEL;
ESTIMATOR = ML;

MODEL:
%WITHIN%
iw1 sw1 | t1l@0 t2l@1 t3l@2;
t1l(1); t2l(1); t3l(1);

iw1 ON genf2 kind chqty famstat medu sport art;
sw1 ON genf2 kind chqty famstat medu sport art;

iw2 sw2 | t1n@0 t2n@1 t3n@2;
t1n(1); t2n(1); t3n(1);

iw2 ON genf2 kind chqty famstat medu sport art;
sw2 ON genf2 kind chqty famstat medu sport art;

%BETWEEN%
ib1 sb1 | t1l@0 t2l@1 t3l@2;
t1l(0); t2l(0); t3l(0);

ib1 ON uce city2 lang small gym lyc;
sb1 ON uce city2 lang small gym lyc;

ib2 sb2 | t1n@0 t2n@1 t3n@2;
t1n(0); t2n(0); t3n(0);

ib2 ON uce city2 lang small gym lyc;
sb2 ON uce city2 lang small gym lyc;

OUTPUT: TECH1 TECH8 STDYX;
```

MODEL 4 (basic predictor model + language + experiment + 'model*language' interaction term)
Between Group

Within Group

```
Title:
Kaz_2015_to_2017_MLM_Growth with covariates;

Data:
File is Z:\model5.csv;
! C:\Users\ICTStudent\Desktop\Analysis\uyghur_growth.df.csv;

Variable:
Names are uce school lang genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n rusexp;

Usevar are uce school lang genf2 city2 kind chqty famstat medu sport art
small gym lyc t1l t2l t3l t1n t2n t3n rusexp;

cluster = school;

within = genf2 kind chqty famstat medu sport art;

between = uce lang city2 small gym lyc rusexp;

ANALYSIS:
TYPE = TWOLEVEL;
ESTIMATOR = ML;

MODEL:
%WITHIN%
iw1 sw1 | t1l@0 t2l@1 t3l@2;
t1l(1); t2l(1); t3l(1);

iw1 ON genf2 kind chqty famstat medu sport art;
sw1 ON genf2 kind chqty famstat medu sport art;

iw2 sw2 | t1n@0 t2n@1 t3n@2;
t1n(1); t2n(1); t3n(1);

iw2 ON genf2 kind chqty famstat medu sport art;
sw2 ON genf2 kind chqty famstat medu sport art;

%BETWEEN%
ib1 sb1 | t1l@0 t2l@1 t3l@2;
t1l(0); t2l(0); t3l(0);

ib1 ON rusexp uce city2 lang small gym lyc;
sb1 ON rusexp uce city2 lang small gym lyc;

ib2 sb2 | t1n@0 t2n@1 t3n@2;
t1n(0); t2n(0); t3n(0);
```

```
ib2 ON rusexp uce city2 lang small gym lyc;
sb2 ON rusexp uce city2 lang small gym lyc;

OUTPUT: TECH1 TECH8 STDYX;
```