

سلسلة أوراق عمل معهد التخطيط القومي

A System Dynamics Model to Study the Primary Education System in Egypt

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نموذج ديناميكي لدراسة نظام التعليم الإبتدائہ في مصر

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ملخص:

تطور هذه الدراسة نموذجًا ديناميكيا لتحليل نظام التعليم الابتدائي في مصر واقتراح مجموعة من السياسات التي تهدف إلى تحسينه، وذلك لتعزيز جودة التعليم الابتدائي. حيث تسلط الضوء على التحديات التي تواجه التعليم الابتدائي، بما في ذلك زيادة كثافة الفصول الدراسية، وارتفاع مؤشر تلميذ لكل مدرس، وتراجع مهارات التفكير لدى الطلاب. اقترحت الدراسة تصميم نموذج ديناميكي لفهم تأثير مجموعة من السياسيات المقترحة على أداء بعض تلك المؤشرات.

من خلال تطوير نموذج شامل لديناميكيات النظام، تم تحليل سيناريو هات متعددة لتقييم التأثير المحتمل اللتدخلات المختلفة.

أشار سيناريو الأعمال كالمعتاد (BAU) إلى أنه بدون تدخل، سيستمر نظام التعليم الابتدائي في التدهور، مع تفاقم كثافة الفصول ونسب الطلاب إلى المعلمين. في المقابل، أظهرت السيناريوهات التي تضمنت تحسينات في البنية التحتية وتدريب المعلمين إمكانات كبيرة للتغيير الإيجابي.

على وجه التحديد، أدى السيناريو الأول، الذي دمج تحسينات البنية التحتية وتوظيف معلمين جدد، إلى انخفاض كثافة الفصول وتحسين نسب الطلاب إلى المعلمين. أظهر السيناريو الثاني، الذي ركز على تدريب المعلمين على مهارات التفكير (HOTS)، تحسينات متواضعة في مهارات التفكير النقدي ولكنه أشار إلى الحاجة إلى تدخلات إضافية للنجاح على المدى الطويل. أظهر السيناريو الثالث، الذي جمع بين تحسينات البنية التحتية وتدريب المؤشرات. ولكنه أشار إلى الحاجة إلى تحسينات المعلمين معلى معلمين معلى معلمين على مهارات التفكير النقدي ولكنه أشار إلى المعلمين على مهارات التفكير (HOTS)، تحسينات متواضعة في مهارات التفكير النقدي ولكنه أشار إلى الحاجة إلى تدخلات إضافية للنجاح على المدى الطويل. أظهر السيناريو الثالث، الذي جمع بين تحسينات البنية التحتية وتدريب المعلمين، التحسينات الأكثر جوهرية عبر جميع المؤشرات الرئيسية.

تؤكد النتائج على ضرورة اتباع نهج سياسي شامل يجمع بين تحسين البنية التحتية للمدارس وبرامج التدريب المهني للمعلمين. تعد مثل هذه الاستراتيجية المتكاملة والشاملة أمرًا حاسمًا لمعالجة المشكلات في قطاع التعليم الابتدائي في مصر وخلق بيئة تعليمية أكثر ملاءمة للطلاب. ينبغي على صانعي السياسات وأصحاب المصلحة النظر في هذه الرؤى لتنفيذ تدخلات فعالة تعزز جودة التعليم ومهارات التفكير النقدي بين طلاب المدارس الابتدائية.

تم اختبار النموذج مقابل البيانات التاريخية من 2016 إلى 2023، من خلال تطبيق سيناريو العمل كالمعتاد (BAU)، بينما تقيم السيناريو هات البديلة التدخلات السياسية. يعتمد السيناريو الأول على توسيع البنية التحتية وتوظيف المعلمين. بيمنا، يقدم السيناريو الثاني تدريب المعلمين على مهارات التفكير (HOTS). ويدمج السيناريو الثالث كلا من السيناريو هين. أوضحت النتائج أن السيناريو الثالث يحقق أفضل النتائج من حيث تحسن مؤشرات كثافة الفصول، ونسب التلاميذ إلى المعلمين، وكذلك مؤشر التفكير النقدي. وهذا يؤكد الحاجة إلى حلول شاملة قائمة على الأدلة تعالج القيود المادية والبشرية والتعليمية لتعزيز وتحسين جودة التعليم.

الكلمات الدالة: نموذج ديناميكي – التعليم الابتدائي- كثافة الفصول – مؤشر تلميذ لكل مدرس – التفكير النقدى

Abstract:

This study develops a system dynamics model to analyze the primary education system in Egypt and explore policies for improvements. The goal of this research is to enhance the quality of primary education in Egypt by developing and utilizing a system dynamics model. The model is designed to understand and predict the impacts of various policy interventions on critical indicators such as class density, pupil-teacher ratios, and the development of critical thinking skills, therefore, the key factors: student enrollment, classrooms, teachers, and critical thinking indicators are studied. The central question guiding the investigation is how the system dynamics model can specifically improve class density, pupil-teacher ratio, and critical thinking skills in Egypt's primary education. The model is tested against historical data from 2016-2023. A business-as-usual (BAU) scenario projects trends, while alternative scenarios evaluate policy interventions. Scenario 1 combines infrastructure expansion and teacher hiring. Scenario 2 introduces teacher training in higher order thinking skills (HOTS). Scenario 3 integrates both scenarios. Results show that Scenario 3 achieves the greatest improvements in class density, pupil-teacher ratios, and critical thinking index. This underscores the need for comprehensive, evidence-based solutions addressing physical, human, and instructional constraints to enhance and improve the quality of education. The model provides a tool for decision-makers and stakeholders to anticipate impacts, optimize resource allocation, and progress towards quality primary education for all.

Keywords: System dynamics - Primary education - Class density - Pupilteacher ratio - Critical thinking -HOTS

1. Introduction

Over the past twenty years, the United Nations (UN) has led efforts to enhance global living conditions across various sectors through two sequential phases of its flagship development initiative. Initiated in 2001, the Millennium Development Goals (MDGs) were operational until 2015, then they were succeeded by the Sustainable Development Goals (SDGs), with a projected timeline extending to 2030. Each of the projects includes a goal focused on education, Goal 2 within the MDGs (MDG 2 'Achieve universal primary education') and Goal 4 within the SDGs (SDG 4 'Quality Education'). Therefore, the primary education is crucial for achieving the sustainable development because it lays the groundwork for individual and societal improvements across various dimensions, including economic, health, social, and environmental aspects, (Kushnir and Nunes 2022).

The Egyptian Constitution of 2014, in Article 19, mandates that "Education is compulsory until the end of the secondary stage or its equivalent. The State shall provide free education in the various stages in the State's educational institutions according to the Law.1" The Constitution also commits the State shall allocate a percentage of government spending to education equivalent to at least 4% of the Gross National Product (GNP), which shall gradually increase to comply with international standards. Article 25 of the Constitution mandates the state to devise a plan to eradicate literacy and digital illiteracy

¹ https://sschr.gov.eg/en/the-egyptian-

 $constitution / \#: \sim: text = We\% 20 are\% 20 drafting\% 20a\% 20 Constitution\% 20 that\% 20 holds\% 20 all\% 20 of\% 20 us, the\% 20 Constitution\% 20 of\% 20 our\% 20 revolution.$

among citizens of all ages, with a defined timetable and the involvement of civil society institutions.

The Seventh pillar, "Education and Training," of the strategic vision for Egypt until 2030 aims to provide high-quality education and training for all without discrimination within an institutional system that is efficient, fair, sustainable, and adaptable. It seeks to be learner-centered, empowering individuals to think critically and possess technical, technological, and vocational skills. The strategic objectives for basic (primary) education until 2030 encompass a set of goals:

The first objective is to enhance the overall quality of the educational system by applying accreditation and global quality standards through the National Authority for Quality Assurance and Accreditation.

The second objective is to provide high-quality education for all students by ensuring there are enough classrooms for everyone.

The third objective aims to improve competitiveness by enhancing education quality and availability in Egypt, thereby improving its rankings in global reports like the Global Competitiveness Report (GCR) and the Human Development Report.

The quality of primary education in Egypt is a key concern for stakeholders. System Dynamics models are valuable tools for integrating and evaluating various policies, offering a comprehensive understanding of the challenges affecting educational quality. These models identify the factors influencing education quality and help improve educational indicators, highlighting crucial areas for focused improvement efforts. System Dynamics is a type of causal modeling used to understand complex systems over time by representing interdependencies and feedback loops among system components. This approach uses causal loop diagrams or stock-and-flow diagrams to graphically depict causal relationships between variables, showing how changes in one variable affect others. By simulating these models, we can explore the propagation of changes through feedback loops, gaining deeper insights into system behavior and the impacts of interventions or policy changes. Thus, System Dynamics effectively uncovers causal relationships driving complex system dynamics (Kurniasih et al. 2023).

System dynamics models differ from statistical models in that they focus on understanding the underlying structure of complex systems rather than merely predicting outcomes based on past data. They provide insights into the interactions of system components over time, including feedback loops, delays, and non-linearities. By incorporating both exogenous and endogenous variables, system dynamics models reveal how changes in one part of the system can affect the entire system. This holistic approach not only aids in prediction and control but also uncovers causal relationships and mechanisms driving system behavior. As a result, these models are particularly useful for designing policies and interventions that address the root causes of complex issues rather than just responding to symptoms (Al Hallak et al. 2019). This study aims to explore how a system dynamics model can be applied to analyze and enhance the primary education system in Egypt. It addresses key issues such as high-class density, unfavorable pupil-teacher ratios, and the insufficient development of critical thinking skills among students. By constructing and utilizing the model, the research simulates various scenarios and policy interventions to understand their potential impacts on these issues. This method provides a comprehensive analysis of current educational challenges and offers data-driven insights and recommendations for policymakers. The central question guiding the investigation is how the system dynamics model can specifically improve class density, pupil-teacher ratio, and critical thinking skills in Egypt's primary education.

2. Overview of the Primary Education System in Egypt

The education system in Egypt relies on centralization in making decisions related to education policies, study systems, curricula, time frame for teaching and preparing curricula, student evaluation systems, teacher recruitment, training, and promotion2. The education system also depends on decentralization in the implementation of teaching processes, technical supervision and follow-up of teachers, procedures for monitoring and evaluating students in their transition to higher classes, and other factors. Hence, education decisions at the national level are made by the Minister of

² https://timssandpirls.bc.edu/timss2019/encyclopedia/pdf/Egypt.pdf

Education, and executive decisions are issued at the governorate level by the Undersecretary of the Ministry of Education in the governorate3.

The primary education facilities to ensure places for all children of school age, which was fixed at 6 years, for a course of six years. therefore, children aged 6-12 were expected in the primary schools. Primary school education is under the direct control and supervision of the Ministry of Education which through its appropriate departments decides curriculum issues. Primary education is free except in the private schools which charge fees.

Egypt's primary education system confronts a multitude of challenges, ranging from issues of quality to overcrowded classrooms, teacher shortages, inadequate teacher training, and a deficiency in teaching critical thinking skills4. These challenges collectively contribute to the declining ranking of Egypt in education quality indices. In response to these pressing issues, a system dynamic model is proposed, leveraging a new model tailored specifically to the complexities of Egypt's primary education landscape. Therefore, the key components and elements of the suggested model are:

Student enrollment through grades are fundamental variables representing the progress of students into the education system and their advancement from one grade to another. These variables are regulated by inflows, such as passing fractions indicating students moving to higher grades, and outflows, such as dropout fractions reflecting students leaving the system prematurely.

³ https://timssandpirls.bc.edu/timss2019/encyclopedia/pdf/Egypt.pdf

⁴ https://www.capmas.gov.eg/Pages/Researchs.aspx?page_id=5031

The management of classrooms are represented by the variable "classes." Classes, considered as physical spaces for teaching and learning, are increased by adding new classrooms and decreased by depreciation or inadequate maintenance. The dynamics of classroom availability and utilization are influenced by feedback loops, such as class density:

Class Density represents the number of students per classroom, can significantly impact the quality of teaching and learning within Egypt's primary education system. Research suggests that high class density can have a detrimental effect on student performance (Kalemba 2022). However, it's important to note that the impact of class density can vary depending on other factors such as the teaching methods used, the subject being taught, and the resources available (Kalemba 2022). This highlights the complex interplay between class density and various educational factors, underscoring the need for comprehensive strategies to optimize classroom environments and enhance learning outcomes.

Teachers represent another key component in the model; they are replenished by new hires and diminished by retirements. In this model, we assumed that teachers could either be trained in modern methods such as Higher-Order Thinking Skills (HOTS) or not yet trained:

HOTS refers to students' abilities to think at a higher level. HOTS are vital for students in the 21st century due to technological advancements like the 4th Industrial Revolution. HOTS has become a global educational objective, shifting focus from mere memorization to fostering skills in analyzing, evaluating, and creating. Without the appropriate skill set and training, it is challenging to expect students to excel in higher-level thinking and reasoning (Sidiq et al. 2021, Kosasih et al. 2022). Many studies have demonstrated HOTS programs can significantly improve students' critical thinking abilities. Research indicates that teachers focused explicitly on developing skills like analysis, evaluation, synthesis and problem-solving leads to meaningful gains (Darling-Hammond 2017, Lombardi et al. 2021, Sidiq et al. 2021, Azid et al. 2022, Kosasih et al. 2022, Khaeruddin et al. 2023, Pradana et al. 2023) Consequently, teachers must equip students with high-level thinking skills, including the ability to analyze, evaluate, and create. In today's educational landscape, curricula and objectives worldwide emphasize the development of students' thinking skills. Therefore, ministries of education might consider designing teaching and learning methods that integrate Higher Order Thinking Skills (HOTS) across all subjects.

HOTS can be applied in elementary schools through various methods and approaches (Pradana et al. 2023), however, the availability of technology and multimedia capable of enhancing HOTs learning is also required, the most prominent of which is the use of fun thinker media based on HOTs questions. Teachers incorporate technology tools and multimedia resources to engage students in interactive and thought-provoking activities. These resources can stimulate critical thinking, encourage exploration, and provide opportunities for problem-solving and creativity (Pradana et al. 2023). Pupil-to-Teacher Ratio: Furthermore, the quality of primary education is also influenced by factors such as the Pupil-to-Teacher Ratio in primary education. The pupil-to-teacher ratio can play a significant role in the effectiveness of teaching critical thinking (Kalemba 2022). A high pupil-to-teacher ratio can make it more challenging for teachers to give individual attention to each student, potentially hindering the development of critical thinking skills. The Global Competitiveness Report (GCR) includes the pupil-to-teacher ratio in primary education as an indicator under the "Skills" pillar, recognizing its importance in assessing the quality of education across different economies. A lower pupil-to-teacher ratio often indicates that teachers can give more individual attention to students, potentially leading to better learning outcomes. In the 2019 the GCR, Egypt was ranked 89th out of 141 countries.

Critical Thinking Index: critical thinking involves asking questions, collecting information, creatively sorting through it, connecting ideas with what has been learned, checking assumptions, and making logical conclusions and decisions. Critical thinking abilities of students must be enhanced in order to fulfill the demands of 21st century learning. One of these is through the use of HOTS-based learning (Pradana et al. 2023). Teachers can assist students by encouraging them to ask questions and reflect on their thought processes, extending beyond the classroom to real-life situations, not only within school but also in their daily lives. Research shows that primary education plays an important role in the development of critical thinking (Facione 2011, Lai 2011, Gelerstein et al. 2016, Lombardi et al. 2021). Critical Thinking in Teaching is