POLICY ACTION NETWORK

PAN TOPICAL GUIDES

AI & DATA SERIES 3

AI AND DATA IN EDUCATION: POLICY CONSIDERATIONS FOR SOUTH AFRICA

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SUMMARY

In South Africa there are high expectations that digital innovations can help a large majority of under-resourced and under-performing schools leapfrog the gap between themselves and a small number of globally competitive peers. From remote teaching and intelligent tutoring to learner management and automated grading systems, digital technologies have been implemented to mitigate some of the resource challenges facing educational institutions while enabling better decision-making in administrative and management processes. Now, emerging data-driven tools, including artificial intelligence (AI) and sub-fields like machine learning (ML), promise a new level of insight and automation for these digital education initiatives. However, as the South African experience has shown, the benefits of emerging technologies in education have been unclear and there are many challenges associated with implementation.

This Topical Guide considers the impact that AI and data-oriented platforms are likely to have on teachers, lecturers, learners and students across the South African educational context. In reviewing emerging trends related to practice and policy on AI and data in education, the Guide recommends a number of actions to facilitate more inclusive benefit from these technologies, including: skills development programs that enable both educators and institution management teams to make optimal use of data-driven technologies in teaching and administration; expansion of digital infrastructure to more schools as an enabler of inclusive AI and data use; stronger support for research into the multi-lingual applications and implications of AI; and legislation, policies and governance arrangements specific to South Africa's education space to encourage innovation that can benefit all learners and educators, whilst protecting users from potential harm.

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ABOUT THIS TOPICAL GUIDE

This series of PAN Topical Guides seeks to provide key research insights and policy considerations for policy-makers, and other interested stakeholders, on how these technologies need to be developed, used and safeguarded in a manner that aligns with the transformation objectives of South Africa. In addition, each Guide outlines ways in which South Africa may respond to the growth of data-driven systems and technologies, including AI, to foster and inculcate a more inclusive and equitable society, rather than deepen divides.

The series is curated by the Policy Action Network (PAN), a project by the Human Sciences Research Council (HSRC) supported by the Department of Science and Innovation (DSI); and the University of Pretoria (UP) South African Sustainable Development Goals (SDG) Hub and Data Science for Social Impact Research Group, under the ABSA UP Chair of Data Science.

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AI AND DATA POSSIBILITIES IN EDUCATION

Most AI applications support decision-making by providing recommendations to users based on an analysis of some input data, such as whether a vehicle captured on CCTV is stolen or whether a person with certain grades and income should be admitted to a university. Machine learning and deep-learning are common techniques used in AI, and require training with large amounts of data to deliver accurate recommendations. These data-driven technologies have much to offer the education sector in terms of enhancing learning experiences and improving management and administration. In particular, there is significant interest in how these intelligent tools can support adaptive learning.

Adaptive and personalised learning systems have been used for many years to deliver customised learning experiences to students based on their individual learning preferences and data history; that is, data on how they learn as well as their individual learning abilities. One common application domain for AI in education is in intelligent tutoring systems (ITS). One of the earliest examples of ITS in South Africa was Dr Maths, a project by the Council for Scientific and Industrial Research (CSIR) which provided mathematics tutoring support in the form of personalised real time assistance from humans, supported by automated language clarification and topic identification.[1] The Dr LOL [2] system, which worked on similar principles, also supported schoolteachers' skills development. Most ITS-like platforms integrate data or learning analytics to track performance and behavioural patterns. By gathering data on students, and using machine learning techniques, an ITS is able to determine a student's learning style and preferences. AI-powered systems can also be used to automate assessments, helping educators understand the cognitive capabilities of students or to identify learning difficulties, whilst reducing administrative workloads.[3] In theory, this enables educators to spend more time on fostering critical thinking and innovation.

In the broader learning environment, AI applications are being used to enhance student engagement and institution management. At Deakin University in Australia, IBM Watson-powered chatbots provide live support to students on issues related to university administration and academic learning processes, including conversational guides to referencing and providing timetabling details.[4] Similarly, in many other schools and universities, management offices have been exploring the use of AI in a variety of areas, from deciding which students to admit[5] to predicting student drop-outs.[6]

EMERGING TECHNOLOGIES IN THE SOUTH AFRICAN EDUCATION CONTEXT

When considering the potential role of AI and data in South Africa, it is important to understand the wider educational context, especially where it concerns the use of technology in education. Data and digital services have been a significant part of South Africa's education system over the years. Pioneering schools and districts have piloted the use of digital learning platforms to enhance learning experiences. In the Gauteng[7] and Western Cape[8] provinces, for instance, provincial Departments of Education introduced 'smart' and digital 'paperless' classroom learning experiences. Other provinces have piloted the use of mobile computing tablets in rural schools.[9] The introduction of whiteboards and tablets has complemented the use of learning management systems that enable access to digital learning material. Pockets of digital innovation have allowed a number of traditional South African public and private schools (and an entirely new segment of digital-first or blended learning schools) to progress towards the integration of advanced technology systems within classroom learning.

The Department of Basic Education (DBE)[10] annual report highlights a substantial investment in skills development focused on the use of ICTs in schools; including laptops, interactive boards, screens and network infrastructure to schools. More recently, the DBE has been exploring the introduction of coding and robotics into primary school curriculums.[11] However, there is a large variation in capabilities and resources to support the use of emerging technologies. For example, a 2019 schools' infrastructure report by the DBE shows that over 80% of primary and high schools in the Gauteng province had computer centres to support the process of electronic teaching and learning, compared to less than 20% of schools in Limpopo. Such variation in computing resources is important for establishing the potential for inclusive and equitable use of AI and data within the learning context.

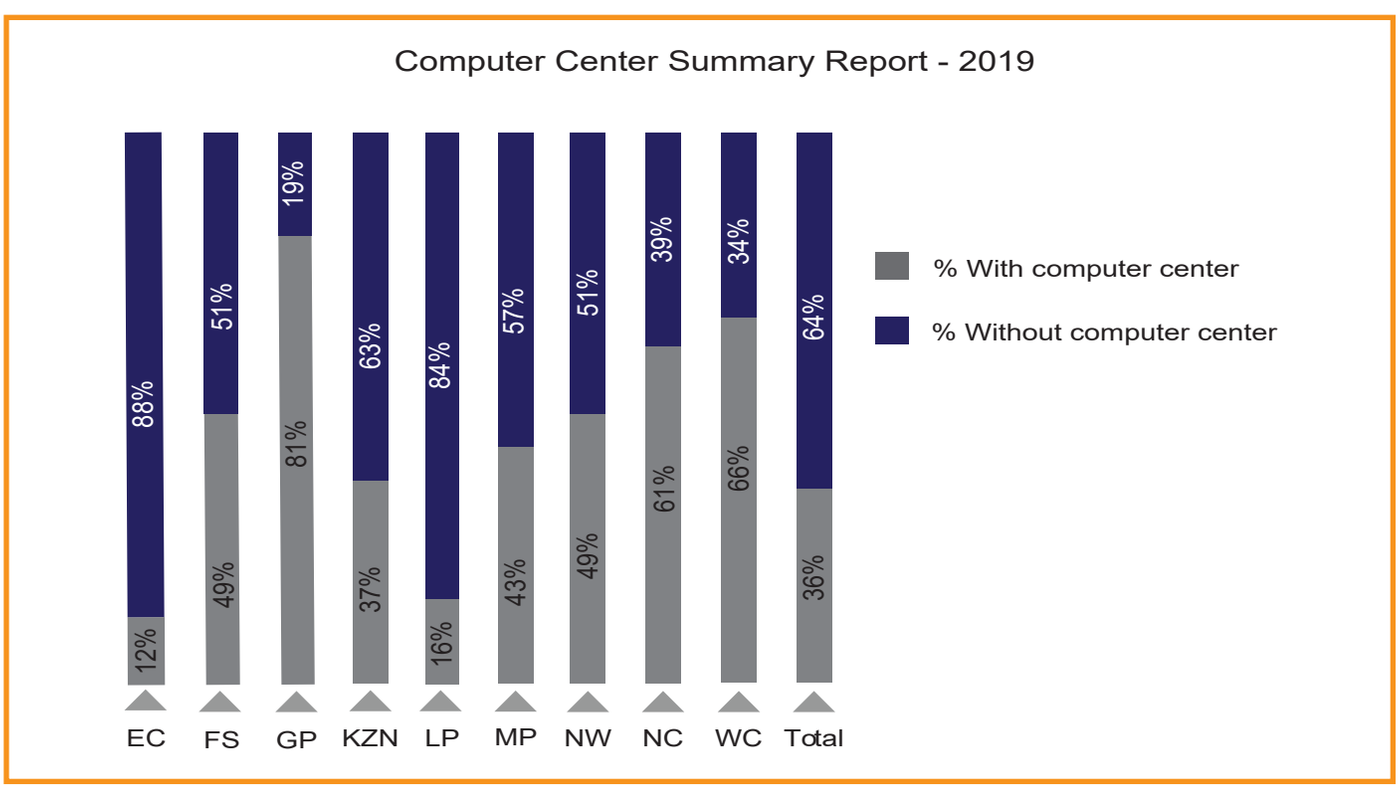


Figure 1. Percentage of schools with computer centres in South Africa, by province.[12]

There are many challenges which schools face in their attempt to adopt electronic and mobile learning, including: unreliable electricity supply; technical challenges with computer labs and computing resources; lack of consistent and long-term training support for teachers and school management on the use of technology in schools; and theft and safety concerns for schools situated in lower income areas.[13] [14]

The importance of these support structures is highlighted by the relatively successful adoption of similar technologies in certain South African universities and private schools which are using learning management systems, teaching robotics, and applying other digital learning resources in the education process.[15]

SOUTH AFRICAN POLICY ON AI AND DATA IN EDUCATION

South Africa's 2004 White Paper on e-Education[16] mandated the use of ICT in all schools as a way to increase access to 'learning opportunities' and 'redress inequality'; and outlined the departments' pledge to ensure that teachers and learners can use pedagogical technology to support instruction. The White Paper identified a variety of potential outcomes relevant to the emerging role of AI and data such as:

- an enriched teaching and learning experience which is now more 'individualised', 'learner-centred', 'active' and 'exploratory';
- improved assessment, incorporating 'analysis techniques' to inform new teaching strategies;
- advances in management and administration to 'automate processes' and improve decision-making.

Broadly, the White Paper anticipated a data-intensive learning environment which is able to understand and respond positively to past, present and future learning trends in each school, district and province. It also acknowledged a number of related issues which are critical to AI and data use such as: continuous capacity building; availability of network infrastructure; information security to 'protect users'; and intellectual property management for 'equitable rights'.

Since the publishing of this White Paper and the split of the department into Higher Education and Basic Education, successive policies and strategies have been issued that speak to the role of technology in education, and now more explicitly to data and AI-related themes. For example, the 2019/20 Department of Basic Education (DBE) annual performance plan[17] lists ICT as a priority intervention, including the introduction of robotics, coding and AI as part of the curriculum. From an education management perspective, tracking learner performance through (national) assessments and data-driven planning now forms a key part of oversight and planning activities. This is largely supported by the SA Schools Management and Administration System (SA-SAMS) and the Learner Unit Record Information Tracking System (LURITS). Projects to monitor the performance and activity of educators have been implemented, however, these face resistance from teacher unions as obsessive 'policing' which is argued to further depress teacher morale.[18]

Similarly, decision-making in the Department of Higher Education and Training (DHET) and related entities is supported by a range of information systems, with a

broader aim of linking supply-side education data with skills demand data from sector skills plans.[19] These are supported by policies and standards governing data quality, dissemination and confidentiality to ensure entities align with the requirements of the Protection of Personal Information Act, 2013 (Act No.4 of 2013) and Promotion of Access to Information Act, 2000 (Act No.2 of 2000)[20].

More broadly, DHET has sought to facilitate a discussion on the impact of the 'Fourth Industrial Revolution' (4IR) on higher education, involving a diversity of representatives from across the higher education sector. Participants provided recommendations on a number of themes such as: developing new technical qualifications which incorporate critical thinking and 'human sciences'; equipping TVET facilities and lecturers to providing training on emerging technologies; supporting data-driven planning by improving data quality and sharing across the post-school education and training (PSET) system; and 'Africanising' the 4IR through relevant policy and curriculum.[21]

Legislation and policies from outside of the education sector are also significant in shaping the direction and discourse around AI and data use in this domain. The Department of Science and Innovation (DSI) 2019 White Paper on Science, Technology and Innovation[22] (STI) emphasises the importance of training young people on 4IR-related technologies (including AI), whilst simultaneously highlighting the importance of critical thinking, emotional intelligence and flexibility; by equipping students to 'to be successful entrepreneurs, hold diverse jobs and work across a number of industries'.[23]

The Department of Communications and Digital Technologies (DCDT) has also coordinated a number of initiatives over the years which have engaged with the role of technology in education, such as the Presidential National Commission on Information Society and Development (PNC on ISAD) and the more recent Presidential Commission on the 4IR.[24] The DCDT's National Integrated ICT Policy White Paper gives a sense of the interventions that DCDT and regulatory agencies drive to support the use of technology in education, which would be relevant to AI and data adoption, such as digital literacy initiatives and the E-Rate (or G-Rate) Regulation to ensure that schools can access the Internet at a discounted rate.

As noted above, the POPI Act aims to regulate data use and handling in South Africa, including by education practitioners and policy actors. Although the POPI Act is not yet fully in force, many schools have internal policies requiring consent as to how learner's personal data is used, including the question of whether or not names and pictures can be posted on social media.[25] In addition, the Copyright Act (and proposed amendment) addresses rights to content and data, as well as exceptions for re-use by education-related entities such as libraries. AI-based applications add a new level of complexity in that these systems may generate their own content, creating uncertainty about ownership and reuse.[26] It is argued that some copyright flexibility is needed to enable South Africans to harness the potential of data-driven innovation and become producers rather than consumers of technology,[27] including in education.

INTERNATIONAL POLICIES ON AI AND DATA IN EDUCATION

In India, a national strategy on AI by NITI Aayog[28], a governmental think tank, considers the role of data-driven technologies in education. The strategy reviews challenges faced by the education sector, many of which are similar to South Africa, and suggests ways in which AI may assist. For example, a key challenge is 'imparting quality education to India's linguistically diverse population', for which India anticipates exporting AI-based solutions to other developing countries.

Other opportunities include personalised learning and automating administration. A collaboration between Microsoft and the state of Andhra Pradesh predicts school dropouts using 'gender, socio-economic demographics, academic performance, school infrastructure and teachers' skills'. The strategy also suggests that implementing AI must be preceded by digitisation of curriculum and teacher and student performance, and highlights risks related to data security, potential bias in algorithms and commercial use of personal data.

In 2017 the State Council of China published the Next Generation Artificial Intelligence Development Plan.[29] This plan includes building and attracting high-end AI talent, as well as establishing AI-related courses at elementary and middle school levels. High schools now have an AI course added to their curriculum, and the revised IT curriculum focuses more on 'data, algorithms, information systems, and the information society' rather than computers and the Internet. On the higher education side, as of May 2018, China had established more than 30 AI colleges, and is encouraging a multi-disciplinary approach to qualifications through compound majors involving, for example, AI and biology, psychology, law and education.[30] AI-enabled systems are also being used widely for the management of campus environments - to control access to facilities, track attendance at classes and to stop 'ghost writers' sitting for exams - all of which raise concerns about use of personal data and whether this level of monitoring is warranted.[31]

In a report commissioned by the Australian National Department of Education, Skills and Employment (DESE)[32], the authors suggest that AI could provide some benefits in the form of personalised learning, but notes that the technology is in the early stages of development and places a relatively strong emphasis on developing ethical and legal frameworks to prevent harm, non-discrimination and ensure accountability. More broadly, the DESE aims to strengthen STEM literacies through a number of initiatives, including an investment of AUD$1.5 Million into 'the development of a range of curriculum resources to assist with the delivery of AI and emerging technologies content and the associated general capabilities in the Australian Curriculum.' They have also set up an online resources hub, a teacher professional learning programme and access to new technologies via the National Lending Library.[33]

RESEARCH PERSPECTIVES AND POLICY CONSIDERATIONS FOR SOUTH AFRICA

In addition to immediate questions about the relative cost-effectiveness of relatively mature technologies, such as individual tablets,[34] in the South African context; there is limited evidence about the effectiveness of AI in teaching and learning globally. A systematic review of research investigating the use of AI in education between the years 2007 and 2018 concluded that there was:

- A low number of papers which provided a critical synopsis of AI in education;
- A low number of papers providing positive relations between pedagogy and data-driven systems; and
- A low number of papers reflecting on issues of ethics in data use and AI being used within education.[35]

There continues to be debate about the value of technology-enabled adaptive learning approaches and data-driven administration of classrooms and institutions. Data and AI-based adaptive learning can be useful in classrooms to enable educators to tailor learning content and experiences based on varying student abilities. However, there is concern that technology-driven and adaptive learning systems are not able to take into account the social and cultural context of students,[36] [37] and that AI-driven educational systems do not consider the underlying learning theories in use.

The relationship between instructional theory and 'dependent technologies', including the role of AI, has been debated since the early 1990s, from three main vantage points; cognitivism – where learning is constructed through an internal thought process; constructivism – relying on personal experiences and impartial knowledge to construct knowledge; and behaviourism – which focusses on fostering new knowledge through stimuli. While learning theories can be incorporated into the development of AI-based education tools, it should be cautiously considered as a complementary process, as the primary aim of achieving learning outcomes needs to remain key in technology support process. The design and build of AI and data-driven tools will require insights from teachers and educational experts regarding issues of context and culture; and a recognition of the relationship between technology design and learning theory. For example, Table 1 shows how different use cases of mobile phone-enabled learning map to different learning theories; potentially providing a framework for how the use of AI and data in education may also be understood.

LEARNING THEORY	DEFINITION	EXAMPLES OF USE	SOUTH AFRICAN EXAMPLES
BEHAVIOURIST LEARNING	Learning has occurred when learners evidence the appropriate reinforcement of an association between a particular response and stimulus.	• Language learning: test, practices, quiz, listening practice speaking • Drill and feedback: mobile response system • Content delivery by text messages	Nokia Mobile Learning for Mathematics Project[38]
COGNITIVE LEARNING	Learning is the acquisition or reorganisation of the cognitive structures through which humans process and store information.	• Using multimedia learning (Dual code, Cognitive Load Theory): images, audio, video, text, animations	Nurse use of mobile tools for learning in rural areas[39]
CONSTRUCTIVE LEARNING	Learning occurs through the construction of knowledge using ideas or concepts based on, previous and current experiences and knowledge	• Questions for exploration • Cases and examples of problem-solving and decision-making applications • Multiple representations • Authentic context-based information database • Collaboration and interaction between students • Communication via mobile phones	UFractions[40] and Dr Maths[41]

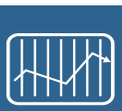
Table 1. Learning theories and mobile technology applications.[42]

AI and data have been adopted in a number of related areas. Automated grading systems can assist with the management of education institutions and individual classrooms, potentially freeing up administrator and educator time, whilst also allowing students to take tests repeatedly and improve their answers. However, caution is needed as students can potentially deceive these grading systems and many of these tools are not able to assess key features of effective communication such as reasoning and ethical stance. Such systems can perpetuate unequal access to education as results from these systems are often used to accept students into a learning institution.[43] As a recent article highlights potential bias in data-driven admission processes is becoming more widely acknowledged. Whilst technology vendors continue to explore ways of mitigating bias, such as by alerting users when a data field for a postal code is correlated with a certain race (significant in a South African context), new challenges will need to be addressed. One of the more well-known issues is historical bias in the data used to train AI-based systems, which tends to favour those who have traditionally been able to access these institutions, and overlooks those from lower-income areas or potential 'late-bloomers'. Well-resourced schools, students and parents will also be better equipped to game automated systems or apply political pressure for algorithmic adjustments.[44]

RECOMMENDATIONS FOR POLICY AND PRACTICE

There is now a need for an extensive, multi-stakeholder engagement process to develop policies that will guide the use and implementation of AI within South Africa's education sector. This process would include educators, policymakers, researchers, innovators, regulators, clients, and providers.

This process is critical to realising the benefits that effective AI use brings in education and working towards the ethical use of such technologies within education, and could address a number of potential topics, including:



Research-informed dialogue – Strategic investment in research supported by appropriately designed public private partnerships is critical for advancing research into the use of data and in AI for education. At the same time, there is a need to expand the national scientific discourse on AI applications in education in order to ensure that it is inclusive and reflective of the local educational needs, whilst also being more accessible to a wider audience. This may include additional multi-sector research colloquiums and critical dialogues[45] for the education and technology communities.

Enabling infrastructure – The significant provincial disparities in access to basic computing infrastructure noted above suggests that the adoption of AI and data-based tools will be highly unequal. Although mobile technologies offer a potential platform for expanding access to AI data-driven applications, we need to recognise the limitations of these channels both in terms of data costs and user experience.

Skills development – Skilling and reskilling needs to be considered through an all-encompassing pipeline from early childhood development through basic education and higher education. This may also include educator exposure to AI and data as part of their early training, as well as ongoing professional development on AI and data-related topics covering content similar to that addressed in the DBE Professional Development Framework for Digital Learning.[46] There is a need to strengthen initiatives for reskilling, while ensuring the placement prospects of employment for reskilled labour within AI.

Language diversity – As highlighted by the India example above, there are potential benefits (and a wider opportunity) in using AI to support increased access to education in multiple languages; a key issue relevant to South Africa. However, local research into natural language processing (NLP) requires large amounts of text data in all South African languages, from book publishers, curriculum developers and media organisations, such as public broadcasters.

Data access and governance – Data quality and sharing have been highlighted as key issues in recent education forums, as enablers of improved decision-making. In addition, because AI is fuelled and supported by data this topic has broader implications. Organisations with access to data need to set-up data sharing frameworks whilst abiding by privacy, transparency and ethics governance guidelines. Such challenges may be averted through transparent data governance processes and consultative reflection on the ethics of data and AI in education.

Policy and coordination – Designing and enacting appropriate policies and legislation (such as POPI) can provide guidance and a mandate to institutions on how data and AI-driven applications should be used without causing harm. There does need to be policies which consider issues around privacy and ethics with specific reference to the education sector. There is also a need for the implementation of policies which support local research and innovation on data and AI in education, as well as the social and legal implications of these technologies. Policy implementation may be supported by national and subnational coordinating bodies, potentially enabled by a national, multi-stakeholder AI committee.

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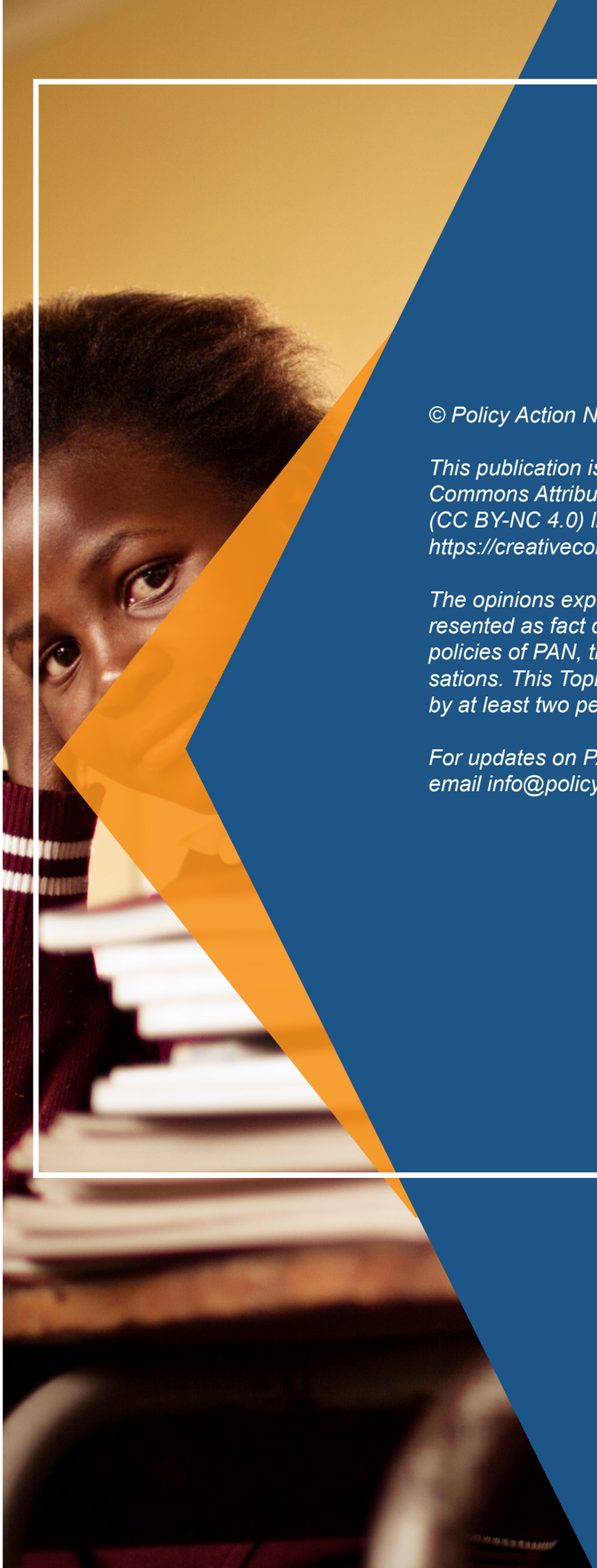

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