Rethinking the integration of ICT in education: Towards a communication model to promote sustainable development

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Abstract. The aim of this study is to reflect on how to integrate ICT (Information and Communication Technologies) into education, adopting an approach that promotes sustainable development through interaction and communication between educational players. The study aims to identify the most effective communication strategies for better integrating ICT into the learning process. Since communication fosters the exchange of ideas on innovative pedagogical practices. This research presents an analysis of trends, gaps and perspectives around sustainable education, focusing on communication and the implementation of educational technologies. The study proposes a new conceptual framework for organizing information sharing between the various players in education. This model places a strong emphasis on how interactions between different actors can contribute to education for sustainable development. The proposed model is a theoretical advance that could guide future research on improving the process of ICT integration and promoting high-quality education.

1 Introduction

In the current era of digital transformation in the education sector, Information and Communication Technologies (ICTs) are a crucial tool for achieving the United Nations-adapted Sustainable Development Goals, including inclusive, equitable and quality education (1). It is in this sense that education policies have evolved to guarantee accessible and equitable education (2). Inclusion advocates postulate that varying and differentiating pedagogical strategies to reach all learners can bring benefits to the school environment (3), and the need to create more flexible and adaptive learning environments (4). Given that ICT offers many tools and methods for the learning process, researchers are looking at how to integrate ICT into education to make teaching/learning activities more inclusive (5). The ecosystem of technology implementation at school level involves several actors and different strategies, with school stakeholders interacting and collaborating with each other, in a complex and interconnected environment. Our problem, then, is to understand how to

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integrate ICT effectively into education to promote sustainable development, while identifying the main obstacles, such as communication problems between educational stakeholders. This paper contributes to this problem by defining the most effective channels for building solid communication in the school ecosystem (6), in order to successfully integrate ICT into education in a way that is both inclusive and sustainable. Indeed, the study proposes a model for structuring communication between stakeholders, with the aim of optimizing the integration of ICT into an inclusive and sustainable educational framework. In order to meet the objectives of this study, this paper is structured in several sections: First, the methodology adopted. Next, a presentation of existing research on the integration of ICT in education for sustainable development. The proposed approach is then presented and discussed, highlighting the communicative aspect. Finally, the conclusion summarizes the main findings, recommendations, limitations and prospects of the study.

2 Methodology

This study is based on a literature review that presents the challenges and opportunities of integrating ICT into education in the context of sustainable development. The references included in this study are selected according to several criteria, namely:

- Publication period: The article presents recently published studies to ensure that the work analyzed is up-to-date and reflects recent advances in the field.
- Source of studies: Studies are extracted from recognized academic databases and international organizations: Google schoolar, Scopus, Web of science, and UNESCO reports.
- Languages: Only publications in English and French were included. Given that these are two languages commonly used in academic literature dealing with topics related to the integration of ICT in education.
- Thematic relevance: The selected studies explicitly address the role of ICT in education in relation to sustainable development to present a wide range of perspectives on the subject.
- Key words: The search is performed using the following keywords: ICT, Sustainable development, Education, Digital integration. The aim is to provide a comprehensive overview of the opportunities and challenges associated with integrating ICT into education to promote sustainable development.

3 Related works

3.1 Education for Sustainable Development

UNESCO's report on Education for Sustainable Development Goals (7), offers education decision-makers a detailed framework for aligning educational practices with the 17 Sustainable Development goals summarized in Figure 1.

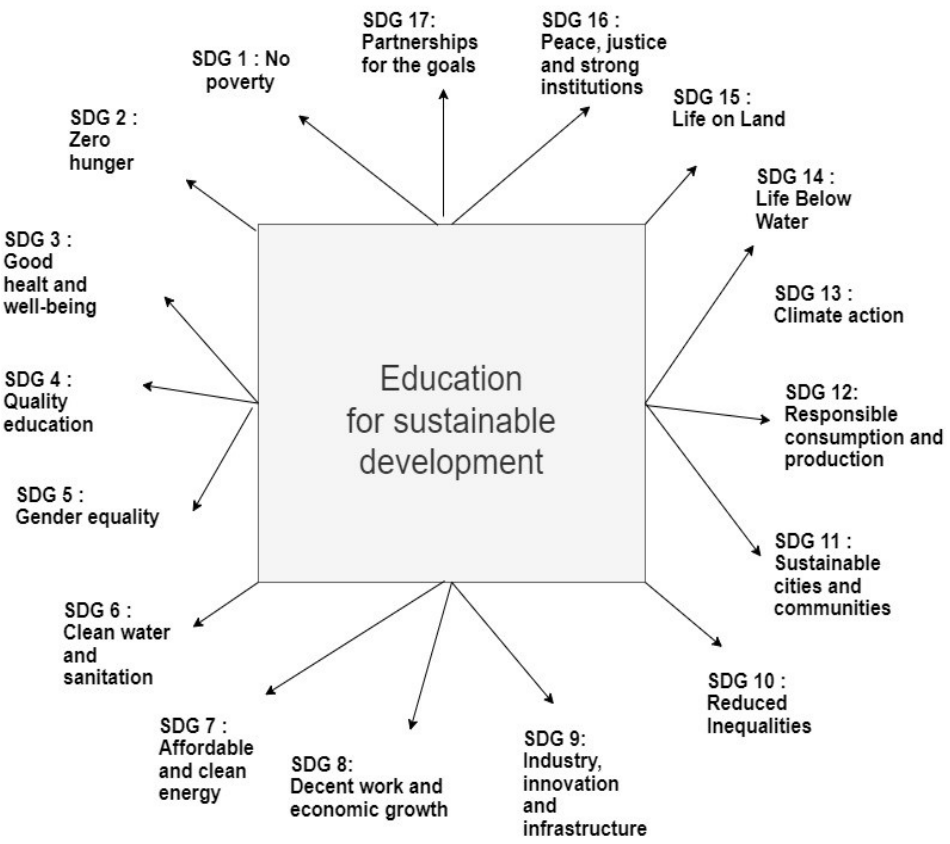

Fig. 1. Education on the 17 Sustainable Development Goals

The UNESCO report calls for a transformative education that is capable of achieving sustainable development. With this in mind, researchers have been looking at various innovative, action-oriented pedagogies. Previous research has shown that project-based pedagogy is capable of involving learners in the resolution of certain real-life issues linked to sustainable development, and that involving learners in school-based projects leads to a practical application of sustainability concepts (8). Other studies have looked at the contribution of active pedagogy to a deeper understanding of sustainable development issues, through debates, group discussions, simulations...etc (9). Thus, interdisciplinary approaches offer a holistic idea of sustainability. These approaches combine different knowledge from various fields to enable an in-depth understanding of sustainability (10). However, the integration of Sustainable Development into the education system faces several major challenges: lack of adequate training, resistance to change in teaching and learning styles, inequitable distribution of resources and services between different regions (11), socio-economic barriers (12)...etc. In addition, the transformation of the world in the context of digitalization requires the integration of ICT into the education system, particularly to promote sustainable development (13)It is in the context of this growing dependence on technology that previous research asserts that ICT offers great opportunities to improve access, quality, efficiency, and sustainability of education (10).

3.2 DevelopmeIntegrating ICT into sustainable education

ICT offers many advantages for sustainable development. In particular, in terms of inclusion and equity. They are potential tools for promoting wider access to education, while offering learning resources and platforms accessible to the entire population (14).. ICTs enable more interactive and motivating teaching that seamlessly combines theory and practice: Learners apply what they learn directly in online forums, discussion platforms, and other digital resources (15). Table 1 presents some of the strengths of ICTs identified in the literature:

Table 1. The strategic advantages of ICT in sustainable education

ICT advantages	Description
Access to information and awareness-raising	ICT enables learners to stay informed on a wide range of subjects and, as a result, develop important knowledge on critical issues. (16).
Developing learners' intellectual and creative skills	The use of a variety of digital tools stimulates critical thinking, problem-solving and creativity. (17).
Increased learner motivation	ICT interactivity makes learning more engaging, capturing learners' interest (18).
Personalized learning	ICTs enable learning paths to be adapted to different learning rhythms and needs. (19).
An enriched learning experience	Multimedia makes concepts more understandable and memorable (20).
More pragmatic learning	Digital tools enable learners to apply their theoretical knowledge immediately (10).
Distance learning and inclusion	ICT offers the solution to distance learning overcoming geographical and socio-economic barriers (21).

Despite the significant advantages of ICT, its integration into education still presents a multidimensional challenge. What's more, ICT adoption is not just technical; it relies on rational communication to guide the necessary interactions and adjustments (22). Indeed, ineffective coordination between stakeholders leads to resistance to change and inequalities of access, hampering the implementation of coherent strategies for ICT adoption in the education sector.

4 Our approach

4.1 A communicative approach to aligning ICT with the goals of sustainable development in education

The communicative approach to ICT integration in education is based on the idea that structured exchanges between the various stakeholders in the education system are crucial to rationalizing the use of educational technology. Indeed, the success of education systems in terms of ICT integration relies not just on digital infrastructure, but on the ability of teachers, learners, administrators, parents and guardians (23), and all collaborators to communicate effectively around techno-pedagogical objectives. A communicative approach can therefore foster structured exchanges, and ensure coherence between digital needs, objectives and practices (24). In this way, the communicative approach aligns with the goals of sustainable development, particularly in terms of inclusive, quality education. For sustainable education is not just about using technology, but also about supporting inclusive practices. These practices require meaningful collaboration between all players. In this sense, digital exchange spaces present a solid tool for involving educational stakeholders in decision-making on: the choice of tools, training, supports and effective strategies for integrating ICT into education (25).For example, parents need to be informed of the added value of ICT to support their children's digital learning. However, their feedback effectively informs the specific needs of learners (26). In conclusion, effective communication is essential to ensure optimized learning.

4.2 Models of communication

Since the late 1940s, the field of communication has seen the emergence of various models and theories. In 1948, two revolutionary theories were introduced: Information theory and cybernetic theory. Shannon laid the foundations of information theory with a mathematical formula that sees communication as a process of signal transmission between a sender and a receiver via a noise-disturbed channel (27). Wiener complemented Shannon's theory by exploring the notion of feedback in his theory of cybernetics (28). Wiener argues that feedback is essential for studying communication processes and understanding how systems self-regulate. During the 1960s-1980s, theorists emerged with the concept of symbolic interactionism (29). This concept is distinguished by its focus on the social aspects of communication through the analysis of interactions between individuals who use symbols to construct meaning, understand each other and coordinate their actions (30). The period between 1980-1990 saw a centralized awareness of the role of the media in the construction of reality (31). The media took on the role of an active player in society rather than a mere reporter of information. They choose which events to cover and which to ignore, and decide how to present them, shaping the way individuals view reality (32)In the 2000s, the network model emerged following the advent of the Internet and the radical transformation propelled by the digital revolution (33). The network model then became the main vector of modern communication. After 2010, researchers began to question the relevance of static models of communication, while viewing communication as an intrinsically dynamic phenomenon that resists any attempt at rigid categorization (34). This transition argues for a more fluid, adaptable approach capable of reflecting the interactive nature of communication. Particularly after the COVID-19 pandemic, which catalyzed the mass adoption of digital communication tools (35). Figure 2 shows a chronology of improved communication models over the years.

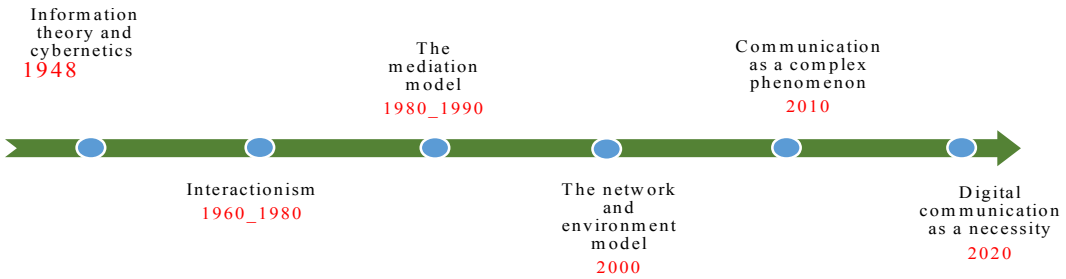

Fig. 2. Chronology of communication model improvements

4.3 Proposal for a new model

The proposed communication model is part of a significant evolution in communication in the digital age. In 2020, digital communication has become an unavoidable necessity, particularly in the field of education, where information and communication technologies (ICT) play a fundamental role in maintaining educational continuity and the fluidity of exchanges between stakeholders. This model takes advantage of digital tools to create a centralised hub that can respond quickly and efficiently to the needs of teachers, students, parents and administrators, while ensuring two-way interaction. By contrast, in the 2010s, communication was seen as a complex phenomenon, involving multiple social, cultural and psychological dimensions. Our model takes this complexity into account by integrating needs analysis mechanisms, a robust technical framework and flexibility in customising exchanges. It enables interactions to be managed holistically, taking into account the diversity of users and their relational dynamics, while reinforcing communication via digital infrastructures adapted to the new paradigms of collaboration and learning.

4.3.1 The main dimensions of the model

The model proposed in this study consists in defining a conceptual framework for exchange between educational players, in order to integrate ICT into education. Referring to previous research work (36) (37) (38) (39), the proposed model takes into account the dimensions represented in figure 3.

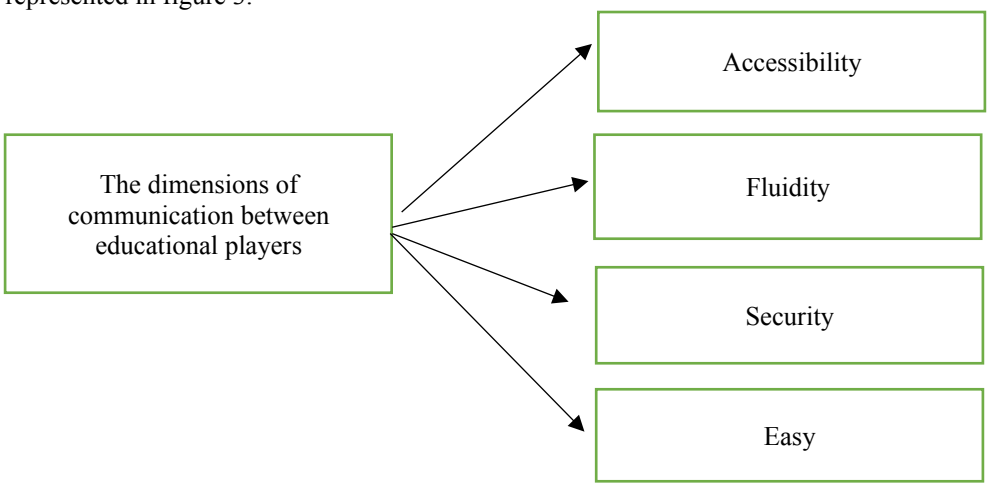

Fig. 3. Main dimensions of the communication model between educational players.

Accessibility: refers to the ability of all stakeholders to access the digital tools and information they need, regardless of their geographical location, technical skills or equipment.

Fluidity: refers to the continuity and speed of exchanges between stakeholders. Thanks to the centralised infrastructure and synchronous and asynchronous communication tools, interactions can take place without interruption, ensuring real-time monitoring and immediate adjustments to teaching needs.

Security is a crucial element in ensuring the protection of data and exchanges, particularly in a digital environment.

Ease; refers to the ergonomics and ease of use of the tools and platform. The user interface is designed to be intuitive and accessible to all users, whatever their level of proficiency in the technologies, thus encouraging rapid adoption and fluid use.

4.3.2 Conceptual framework

The proposal of this study is to create a digital environment that enables all these players to interact and collaborate with each other (see figure 4).

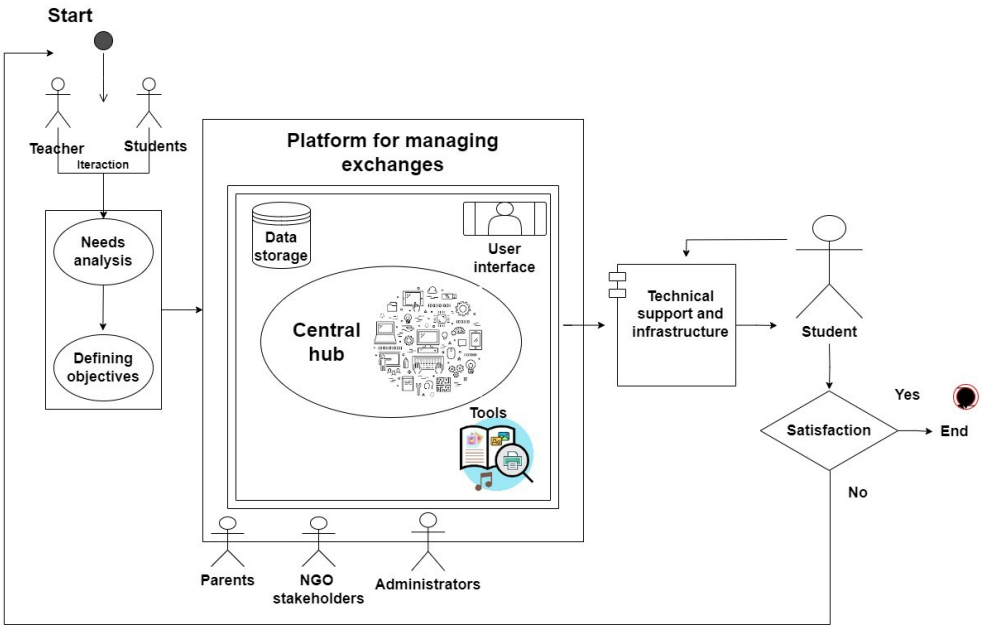

Fig. 4. Conceptual framework for the collaborative integration of ICT in education.

The proposed communication model is based on a series of dynamic and interdependent interactions between the various players in the education system: teachers, students, parents, NGOs and administrators. These interactions are facilitated by a central platform that acts as a communication hub, integrating the dimensions of accessibility, fluidity, security and ease. Each player contributes to an ecosystem of information sharing and collaboration, where educational needs and objectives are analysed and adapted in real time.

Teachers and students are at the heart of this system, with constant interaction to adjust educational content and teaching methods, while gathering feedback. Parents, NGOs and administrators participate through dedicated channels, providing external perspectives, support and additional resources. The underlying technical infrastructure supports these exchanges by guaranteeing stable connectivity and permanent access to digital tools, ensuring continuous and responsive two-way communication. This model of interaction optimises teaching processes while facilitating effective coordination between the various players.

- Students are at the center of the school ecosystem: they are involved in learning activities, collaborate with each other to acquire new skills and participate in defining objectives. ICT offers them an opportunity to explore and discover concepts at their own pace, plan their own study time (autonomy), develop the capacity for creativity and self-regulation of learning by giving them the possibility of self-assessment.
- Teachers are the key players in the school ecosystem, playing the role of facilitators which includes planning lessons and activities taking into account differentiated instruction to meet the needs of different students, motivating and engaging them, as well as assessing student progress in real time and online. They can also choose the technological tool that is accessible to all students and check its compatibility with the other technologies used in the school system, ensuring that the tool is available at a reasonable cost. Teachers can also train students in digital skills.
- Parents and guardians are involved in engaging students in learning activities planned by teachers, motivating students to achieve goals and monitoring students' online activities to ensure that ICT is used effectively and appropriately.
- NGOs can support the integration of ICT by providing uniform technological materials to the educational program and by offering adequate training to teachers.
- Administrators can ensure successful collaboration between teachers, parents and community partners, for effective use of ICTs; they can assess the effectiveness of educational programs to improve them, and guide and support the efforts of other players.

The framework for integrating ICT into education that we are proposing structures exchanges between educational stakeholders within the framework of sustainable development, and this is explained by its alignment with several sustainable development goals, namely :

SDG 4: Quality education

The platform enables stakeholders to work together to support learning through the personalization of educational objectives. In this way, monitoring learner satisfaction helps to optimize the learning process. This converges towards inclusive, equitable, quality education.

SDG 9: Industry, innovation and infrastructure

The platform relies on the use of ICT to facilitate access to educational tools, providing leverage for innovation.

SDG 10: Reducing inequalities

The proposed framework allows for the broad sharing of good teaching practices, thereby reducing inequalities linked to the quality of education.

SDG 16: Peace, justice and effective institutions

The use of an interface that centralises exchanges can contribute to more informed decision-making, thereby promoting good governance of the education system.

SDG 17: Partnerships to achieve the goals

The proposed framework involves a number of players: NGOs (non-governmental organisations), administrators, and so on. This reflects several partnerships within the education system.

The proposed framework can also make a cross-cutting contribution to the other SDGs, by contributing, for example, to climate change education or human rights education.... etc. The aim is to prepare tomorrow's citizens by encouraging learners to adopt responsible and sustainable behaviour.

5 Conclusion

Education for sustainable development is a major challenge for education systems. It requires a central approach to tackling the challenges of social and economic inequality. It is in this sense that the use of ICT represents a strategic lever for improving access to educational resources and enhancing the quality of learning. Thus, the proposal for a conceptual framework adopting a communicative approach to the integration of ICT aims to create a collaborative environment to align with the objectives of sustainable development. The framework proposed in this study takes account not only of the technical infrastructures, but also of the exchange processes between educational players. This convergence between the communicative approach, education, ICT and the objectives of sustainable development opens up promising prospects for researchers and specialists in the field of education, in the sense of conducting research into the development of diversified training programmes based on technological reality, as well as the development of innovative tools in the context of education for sustainable development.

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