Investigating Mid-Level IT Affordances as Drivers for Societal Change: Addressing the Education Data Challenge in The Gambia [PREPRINT, IFIP 9.4 2022, Track 7]

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Investigating Mid-Level IT Affordances as Drivers for Societal Change: Addressing the Education Data Challenge in The Gambia

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Abstract: Affordance perspectives have gained traction among information systems (IS) scholars and have seen recent adoption in ICT4D research. Although scholars recognize the need to differentiate between mere technology use and higher-level organizational and societal IT affordances, no clear terminology for the representation of affordance granularity exists. This paper introduces "mid-level IT affordances", which, we argue, emerge from technology use and serve as prerequisites for the actualization of higher-level affordances. To illustrate, we draw on a case study of education management information systems in The Gambia. International development agendas encourage public sector actors to produce increasingly granular data. Yet, the capacity to utilize the data is not strengthened correspondingly. This introduces a disconnect between policy and practice, whereby investments in technology use affordances fail to translate into IT affordances for monitoring progress towards complex policy goals. A mid-level IT affordance perspective allows for the identification and potential mitigation of such gaps.

Keywords: Mid-level IT affordances, education management, SDGs.

1. Introduction

A theoretical challenge identified by information systems (IS) scholars pertains to the level of granularity of affordances. DeSanctis and Poole [1] introduce the term "repeating decomposition problem", pointing at the fact that "there are features within features (e.g., options within software options) and contingencies within contingencies (e.g., tasks within tasks)" and raise the question, "how far must the analysis go to bring consistent, meaningful results?" (p. 124). To date, there is no clear consensus on how best to conceptualize the aggregation of affordances from "simple" (e.g., tagging [2]; inputting data [3]; searching [4]) to more complex composite affordances at the organizational and societal level (e.g., clinical decision-making [3]; developing concepts [4]; organizational memory affordance [5]; Enhancing Knowledgeability and Autonomy [6]). Accounting for the intricate relationship between technology use and its implications for social development is at the heart of the ICT4D research agenda. Further development of an affordance perspective is promising in this regard.

Technology is not a panacea for development [7, p. 12]. Yet, the development landscape is fraught with ICT interventions to improve the lives of the world's poor (e.g., [8]). Faik et al. [6] point out that there is limited attention to "how [societal consequences] emerge from the development, deployment, or use of IT" (p. 1361). To this end, the authors attempt to develop an analysis that ties IT use affordances directly to societal changes. Inspired by this recent work, we argue that the recognition of "mid-level IT affordances" allows us to trace and account for the action possibilities that emerge from basic technology use (lower-level affordances). In turn, we argue, "mid-level IT affordances" are constitutive of higher-level affordances that are associated with social development, such as improved health and wellbeing of populations or equitable access to quality education.

This study reports from the Gambian education sector, where the Ministry of Basic and Secondary Education (MoBSE) has engaged in an "Education Management Information Systems shift", a stepwise digitization initiative, that entails the transition from reliance on surveys and aggregate statistics to individual learner records. Until recently, the EMIS was an aggregated and paper-based data system, managed at the national level and characterized by fragmented data [9, p. 129]. The existing information system could not explain why learning outcomes in the country remained low while the proportion of qualified teachers increased. More recently, it could not respond to information needs regarding the effect

of school closures during the Covid-19 pandemic, nor guide interventions to alleviate the situation for out of school learners.

MoBSE, like many other ministries of education, were unable to produce data to monitor progress towards some of the key Sustainable Development Goals (SDGs), which aim to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" [10]. This includes ensuring "equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations". Consequently, "data needs to be disaggregated by gender, location, wealth quintile and other factors" [11, p. 9]. This necessitates processing of individual learner data. MoBSE experienced a policy-practice gap, whereby national and international policies called for increasingly granular data, while the education system's capacity to record, interpret and utilize the data for local action remained scarce.

This paper draws on and extends an affordance perspective [12], to explore the action possibilities the "EMIS Shift" affords education management in The Gambia. Our main contribution is the introduction of "mid-level IT affordances" to IT affordance research. An affordance perspective allows us to study action possibilities associated with IT adoption, implementation and use at an organizational "mid-level" (e.g., [13–17]). In ICT4D research, affordance perspectives are hitherto underutilized, although there are recent promising examples (e.g., [18–20]). A widely adopted definition of affordances in IS research, is that an affordances is "the potential for behaviors associated with achieving an immediate concrete outcome and arising from the relation between an artifact and a goal-oriented actor or actors" [16, p. 69, 17, p. 823].

In this paper, we map the interdependence between "simple", or lower-level, technology feature use affordances (e.g., inputting data) to mid-level affordances (i.e., organizational IT capabilities) such as *decentralizing data access*. Finally, we relate these mid-level affordances to higher-level affordances, which afford the education sector in The Gambia the ability to *monitor progress* towards the SDGs and national policy goals (i.e., societal changes [6]). The structure of the paper is as follows. In the next section, we provide an overview of relevant IT affordance literature. Next, we present our method. In Section 4 we present our empirical case and discuss the case findings before we in Section 5 consider how the Gambian EMIS case underscores the importance of understanding the composite, interdependent, and delicate nature of IT affordance realization in public sector organizations in the Global South.

2. IT Affordances at Different Levels of Granularity

Gibson [21-22] first introduced the concept of affordances to the field of evolutionary psychology while arguing that animals do not perceive the objects' physical properties, but rather what objects can provide: "The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill*"* [22, p. 127]. A shelter affords sheltering to animals, and a knife affords cutting to people. Since different actors have different capabilities, affordances are not the same for all actors. For instance, stairs afford climbing to most people, but not to infants or people with certain disabilities. While affordances can be easy to perceive and actualize for "simple" objects (e.g., a knife), the application of AT to the IS field has proven difficult. In an organizational context, a complex information system affords a plethora of different action possibilities to an array of different actors.

Markus and Silver [23] warn that repeating decomposition of IT feature usage might pose analytical challenges and suggest to "hypothesize that the system as a whole, rather than one or more component parts, provides an affordance" (p. 628). Nonetheless, a complex information system in an organization setting affords a number of desirable action possibilities that somehow needs to be perceived and realized by organizational actors. Gutek et al. [24] notes that most computer systems are really "sets of loosely bundled capabilities and can be implemented in many different ways" (p. 234, as cited in DeSanctis & Poole [1, p. 126]). Leidner et al. [14] urge researchers to look beyond mere technology use, while Volkoff and Strong [25] highlight that researchers should study affordances at an appropriate level of granularity. To date, there is no clear guidance on how to identify and label such different granularity levels of IT affordances. This is needed, we hold, to study the relationship between changing IT use affordances and societal development and to generate a coherent body of knowledge.

2.1. Towards an ensemble view of IT affordances

The decomposability of affordances has given rise to several theoretical constructs in IS research. Strong et al. [16] illustrate affordances' interdependency through the *affordance dependency diagram.* Similarly, Burton-Jones and Volkoff's [3] *affordance network* explains how affordances are interrelated. Both these concepts allude to how the actualization of an affordance can lead to the emergence of another affordance. Thapa and Sein [19] extend this line of reasoning and introduce the *trajectory of affordances*, that is, the trajectory along which affordances travel, "specifying the process and conditions through which affordances are perceived leading to actualisation of affordances" (p. 811). They also argue that affordances form *ensembles*. Interestingly, these notions all resemble ideas introduced by Gaver [26] more than two decades earlier: "Complex actions can be understood in terms of groups of affordances that are *sequential in time* [emphasis added] or *nested in space* [emphasis added]" (p. 79).

As an illustration of sequential affordances, Gaver [26] explains how a door handle affords turning *after* the grasping affordance (i.e., grasping the door handle) has been actualized. He distinguishes sequential affordance (in time) from nested affordances (in space), as he explains how the *door opening* affordance consists of the affordances *pulling the door handle* and *pulling the door*. Drawing on Gaver, Bernardi [27] refers to nested affordances as *composite affordances* and provides an example of how the *building a support network* affordance is a composite of the *self-presentation* and *narration* affordances. We have visualized Gaver's ideas in Figure 1, and in Figure 2 we have replaced Gaver's affordances with generic terms. This simple framework served as a starting point for our study of affordances in the Gambian EMIS Shift implementation.

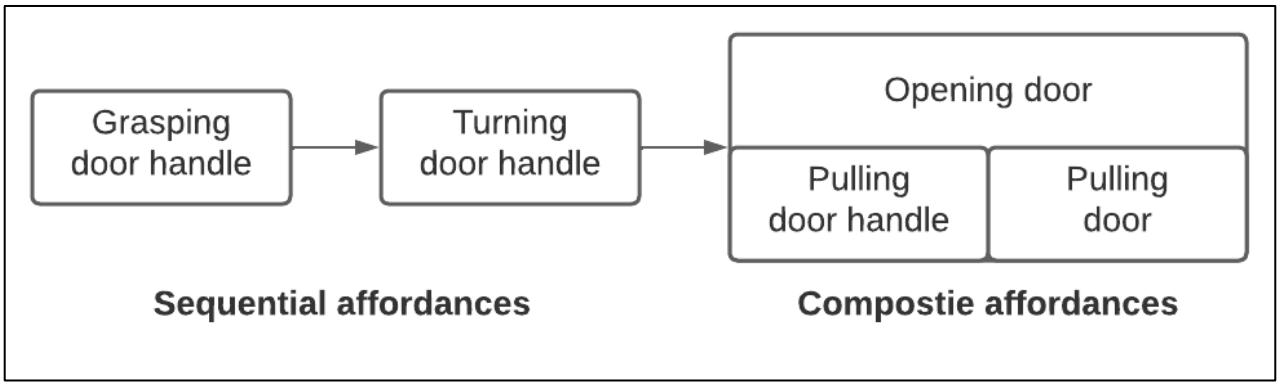

Figure 1. Conceptual framework derived from Gaver [26], using Gaver's affordances

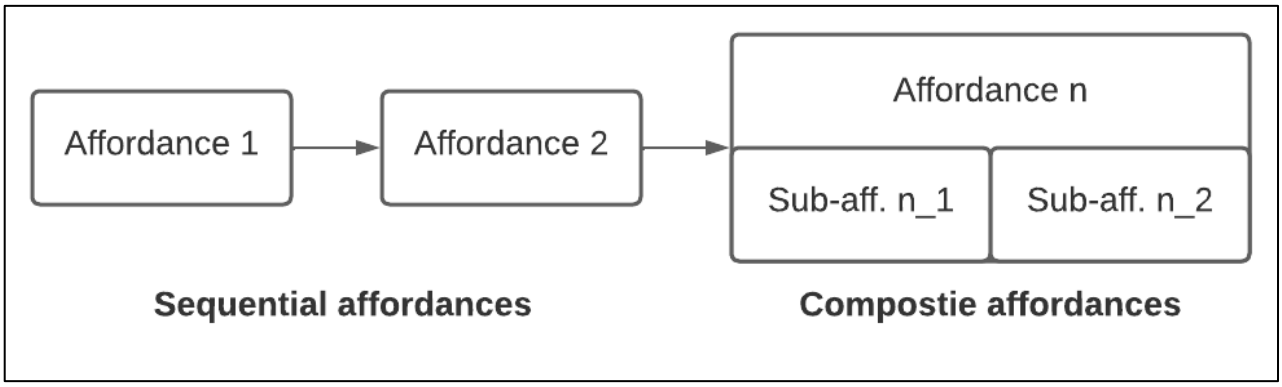

Figure 2. Conceptual framework derived from Gaver [26], using generic terms

2.2. Gaps

Although IS scholars have shown that there is interdependency between affordances and that the IT affordances of most interest reside on a higher level of abstraction, there is a gap in the literature on how to identify and characterize these affordances. Extant literature mentions lower and higher level (e.g., [3]), first- and second-order [14], and individual- and organizational-level [16] affordances. In this paper we introduce "mid-level IT affordances" to signify affordances that emerge as a consequence of technology use and are constitutive to the higher-level affordances.

In the following methods section, we describe the case context, and in the subsequent section we argue how IS scholars may investigate affordance interdependencies, by recognizing their *composite* and *sequential* nature, across three different levels of granularity (low, mid, and high).

3. Method

3.1. Case Bakckground

This study reports from an ongoing research endeavor in The Gambia, coordinated by the Health Information Systems Programme (HISP) center at the University of Oslo. The Gambia, like many other ministries of health in low- and middle-income countries, has been using the open-source District Health Information Software 2 (DHIS2[1]) as a nation-wide health management information system (HMIS) since 2010 [28] and is now expanding the usage of DHIS2 into the educational domain, implementing it as their national education management information system (EMIS). To meet the demand of individual data reporting, put forth by the SDG4 and national goals of improved learning outcomes across

[1] https://dhis2.org/

social stratifications, the need for an information system which could disaggregate data to individual level was identified. The positive experience from the health domain and the establishment of relevant in-country technical capacity resulted in the selection of DHIS2 as a backbone for the nationwide EMIS implementation. Despite its historical association with the public health sector, DHIS2 offers a set of generic data models and customizable modules that are deliberately domain agnostic. The on-going appropriation of DHIS2 to the education sector is driven by countries that already have developed a strong national capacity to utilize DHIS2 for health and wish to capitalize on this also in education.

As part of the digitalization initiative MoBSE has implemented DHIS2 as the backbone of its national EMIS. DHIS2 is a modular and complex digital platform system, consisting of a software core onto which new contents, applications or services can be developed. The development and implementation of such compliments are facilitated by DHIS2's software development kits, design systems, documentation and open application programming interfaces (APIs). To utilize the flexibility of DHIS2, MoBSE in The Gambia needs to obtain local capacity to configure and customize existing DHIS2 modules and develop and maintain complimentary applications when necessary.

Table 1. Data sources

Data source	**Type**
Education Sector Strategic Plan 2016-2030 [9]	Official Gambian government publication
The shift from aggregate to individual-level data system in the case of The Gambia EMIS (Internal project document)	PhD Proposal to the University of Oslo by a MoBSE employee
Meeting the global learning crisis with data: a research agenda on digital platforms for education management [29]	Research opinion article (manuscript in preparation)
Information system centralization and decentralization: The introduction of digital learner records in The Gambia [30]	Conference article (manuscript in preparation)
17 Bi-weekly EMIS status and update meeting Participants: ● The EMIS project manager (HISP center) ● 3 scientific staff (HISP center, including second author) ● 1 PhD Research fellow (first author) ● Representatives from national EMIS implementations o The Gambia (2) o Uganda (4) o Mozambique (1) o Sri Lanka (1) o Togo (2)	Recurrent meeting with local stakeholders for EMIS implementations in The Gambia, Uganda, Mozambique, Sri Lanka, and Togo
20 Bi-weekly EMIS project coordination meeting Participants: ● The EMIS project management team o The EMIS project manager o 1 Professor o 1 Associate professor (second author) o 1 Senior engineer ● 1 PhD Research fellow (first author)	Recurrent meeting for HISP's EMIS project management team at the HISP center (UiO)
18 Bi-weekly research meeting. Participants: ● 3 scientific employees at the HISP center o 1 Professor o 2 Associate professors (including second author) ● 3 PhD research fellows o 1 MoBSE employee currently doing a PhD at UiO studying the Gambian *EMIS shift* towards individual data collection and reporting. o 1 HISP Uganda employee involved in the expansion of DHIS2 from the health sector to the education sector. Doing a PhD studying disaggregation of decision-making in the Ugandan education sector. o 1 PhD research fellow at the HISP center, studying the implementation of DHIS2-EMIS in The Gambia and Uganda (first author).	Recurrent meeting among PhD research fellows studying EMIS implementations in The Gambia and Uganda
6 interviews of employees at different levels of the educational system in The Gambia. The average interview duration was approximately 30 minutes.	Semi-structured interviews. Snowballing used to identify interviewees.

3.2. Data Collection and Analysis

Through field trips, interviews, and recurrent biweekly online meetings with representatives from MoBSE, the authors have continuously engaged with the Gambian implementation of DHIS2-EMIS over a period of 16 months. We reviewed relevant official documents to further contextualize the case study. Table 1 gives an overview of the data sources. We identified a set of affordances related to the ongoing DHIS2-EMIS implementation and organized these into themes, with the help of the conceptual framework we derived from Gaver's [26] work (Figure 2). This allowed us to engage with the clustered and sequential nature of the identified affordances and explore the interdependencies between lower- and higher-level affordances. Our analyses revealed the need for a terminology that can describe affordances that are neither basic lower-level affordances nor very abstract higher-level affordances. Hence, we introduce the notion of "mid-level affordances" to bridge this gap.

4. Case Description

4.1. Configuring DHIS2 for Education Management

DHIS2 is an open-source management information software platform, used by 73 ministries of health [31] and six ministries of education [32]. DHIS2 development is coordinated by the HISP center at the University of Oslo. HISP is a research and implementation network, with 15 recognized HISP groups around the world and numerous other contributors. Recently, DHIS2 has been adopted in several new domains, such as agriculture, road safety, logistics management, and education management [33]. For more than a decade, The Gambia has been using DHIS2 as an HMIS. The Ministry of Basic and Secondary Education (MoBSE) have since 2019 adopted DHIS2 as a backbone for its EMIS. DHIS2 can be used for both individual records keeping and aggregate data collection and analysis. MoBSE wishes to leverage DHIS2 to meet EMIS requirements put forth by the SDG4 and national goals of improved learning outcomes across social stratifications.

DHIS2 is a rather complex piece of software, with a platform architecture. This grants local design flexibility, for those who have the necessary capacity to configure DHIS2's "bundled applications" or develop platform extensions themselves. A freshly installed instance of DHIS2 requires configuration in terms of setting up organizational hierarchies and creating data elements and indicators which data collectors will report against and analysts will monitor. By taking advantage of DHIS2's software development kits, APIs, design tools and documentation it is possible to create software extensions or applications that can be loosely integrated with the platform core. These apps can also be uploaded to the DHIS2 App Hub, which makes them available for other user organizations to download and install on their DHIS2 instances.

Since DHIS2 is open source, the entire source code can be modified by anyone with the right skill sets. However, as the DHIS2 core is maintained and governed by HISP at the University of Oslo (HISP UiO), actors with core software requirements engage with the HISP UiO development team to have their requirements recognized in the DHIS2 roadmap. Through two decades of north-south-south university collaborations, a large network of experts has emerged to cater for public sector DHIS2 implementation needs. Implementations are often organized as participatory co-creation projects involving HISP UiO, a local regional or national HISP group and a ministerial department as partners. In addition to knowledge sharing through projects, there are formalized training structures referred to as DHIS2 Academies as well as a vibrant online community of practice, where local problem owners can find advice and support from experienced members of the community.

4.2. Gambian DHIS2-EMIS configurations

Data Visibility at All Levels. DHIS2 affords education sector administrators the possibility of creating custom analytics dashboards and analysis tools using for example pivot tables, graphs, or maps. Nine members of the MoBSE national level team received training from HISP West and Central Africa (HISP WCA) on how to configure relevant thematic dashboards and analysis tools. The national team can now design their own thematic dashboards and share these with users at sub-levels. Ideally, given sufficient organizational capacity, each organizational level could be trained to develop custom dashboards for the level below themselves in the hierarchy. Hence, the national level would make dashboards for the regions and the regional offices would make dashboards for schools in their regions. Furthermore, each level can make their own dashboards or adjust the dashboards received from a higher level to account for local priorities and circumstances. Given sufficient training in software configuration and data analysis, each school can visualize its own data and inspect relevant indicators for their own planning and management (e.g., teacher and student attendance, dropout, and completion rates by relevant group disaggregations, etc.). Similarly, cluster monitors – school inspectors responsible for following up a cluster of schools within a region – have access to a different dashboard and analysis setup and can inspect school performance and reporting rates. At national level, MoBSE has access to all data in the system and has yet another dashboard and data visualization setup to be able to monitor broad trends and evaluate national education sector programs. Figure 3 provides an example of a DHIS2-EMIS dashboard.

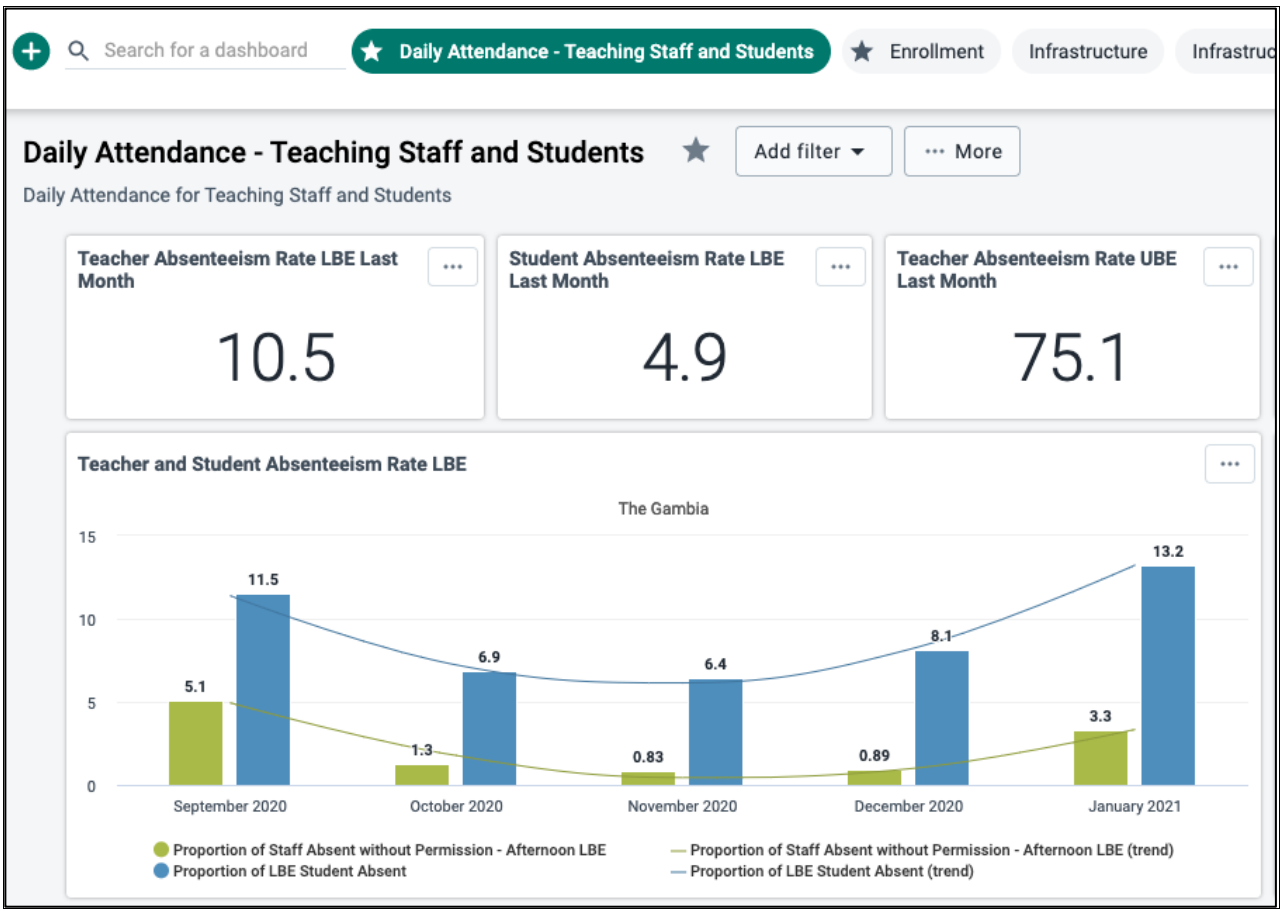

Figure 3. DHIS2-EMIS dashboard showing daily attendance trend in lower basic education (LBE) units in The Gambia. Demo data may not correlate with actual figures.

Data Disaggregation. MoBSE in The Gambia decided to redesign its EMIS, which was essentially based on Microsoft Excel, Access databases and paper-based data collection tools, in order to cater for the novel socio-economic disaggregation requirements of education data. Internally, this process has been called the "EMIS shift", as it entails a shift from handling purely aggregated data (statistics) to also maintaining individual learner records.

MoBSE perceived the possibility of using DHIS2's Tracker module - a generic module for capturing data over time about any type of tracked entity - to capture and store educational data on individuals. The Tracker module is used in public health implementations of DHIS2 to store medical information on patients from their recurring visits to a clinic or to record data about trajectories of blood samples or health commodities. The module supports storing (constant) information about the tracked entity as well as data that varies over time. Thus, MoBSE decided to use the Tracker module to collect and store socio-economic data, attendance history, and continuous assessment data about learners.

Exploiting the design flexibility of DHIS2, MoBSE, in collaboration with HISP WCA, configured individual learner modules to be able to follow-up individual students. The modules were designed through participatory methods where HISP WCA first engaged in capacity building workshops in order to inform MoBSE about the different design possibilities. In the configured modules, MoBSE captures the learners' socio-economic data, attendance history, continuous assessment, and disciplinary record. During 2020, MoBSE implemented individual learner admission and registration by employing a combination of DHIS2, mobile data traffic, and Chromebooks in 200 schools. The technical resources from the initial phase were further leveraged to collect and register students throughout public schools in the entire country. Beyond individual record keeping, the individual data can be anonymized and aggregated to provide useful information for secondary administrative use.

Digitized School Report Card. The Gambian school report card (SRC) is a school-level information product intended to promote community participation and increase accountability and transparency. The tool highlights priority areas for the coming year and informs the preparation of school improvement plans. In 2008, the first version of the SRC was created. Although there have been challenges using the SRC, it has been widely recognized and embedded in the country's EMIS practice. A limitation of the initial version was that sub-national levels could not access the data directly and had to wait for distributed printouts from the central level. This hindered broad engagement from regional officers,

head teachers, parents, and community representatives in a timely manner. Furthermore, despite the focus on simplicity and visual guidance in designing the SRC, evaluations revealed challenges associated with interpretation of results.

By taking advantage of DHIS2's API, MoBSE, in collaboration with HISP WCA, and three informatics master students from UiO, developed a new web-application of the SRC – a DHIS2 addon – which could be integrated into the Gambian DHIS2-EMIS instance. Consequently, SRC data access can be granted to DHIS2-EMIS users and has allowed for decentralized access and improved availability and use. To support local use of the SRC, the web-application features a printer friendly version that can be printed at schools or nearby printing facilities. Figure 4 shows the remodeled SRC in DHIS2-EMIS.

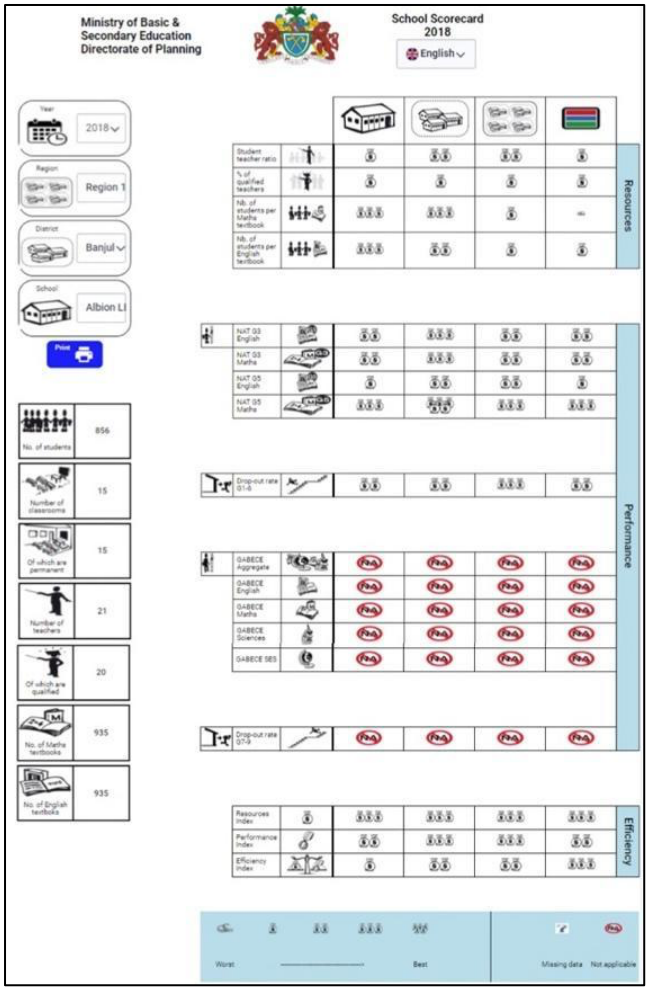

Figure 4. The digitized school report card in the Gambian DHIS2-EMIS instance

5. Discussion

5.1. Granularity Levels

Volkoff and Strong [25, p. 241] argue the importance of selecting "an appropriate level(s) of granularity for the affordances". They point out that Strong et al.'s [16] widely accepted definition of IT affordances does not say anything about which granularity level is appropriate. Affordances can be decomposed to lower-level affordances and aggregated to higher-level affordances. To examine how DHIS2-EMIS affords informed decision-making that puts the Gambian education system on track to improve learning outcomes and social inclusion, it follows that the most relevant granularity level is at the level of the organization.

A problem with studying affordances at the organizational level (mid- or higher-level affordance), however, is the difficulty of distinguishing the affordance itself from its outcome, when the affordance is actualized. Volkoff and Strong give an example of *visibility,* which several researchers have identified as an affordance (e.g., [34–37]). Visibility, in itself, is not an affordance but "a state, and masks the associated actions – and even the actor" [25, p. 242]. In the following we address this concern and argue that an organizational affordance, or action possibility, emerges from the actualization of an array of lower-level affordances. This view is consistent with IS researchers' prior arguments regarding the decomposability of affordances (e.g., [23, 25]).

5.2. DHIS2-EMIS Affordances

The DHIS2 platform, implemented in The Gambia as an EMIS backbone, affords action possibilities to education sector stakeholders. The most "hands-on" affordances, such as *configuring* the readily installed instance, *developing* and *integrating* an addon application, or *rewriting* the source code are readily perceived. However, in the following subsections we argue that, at a higher level of granularity, *decentralizing data access, educational decision-making,* and *ensuring equal access to quality education* are three affordances that emerge in the relation between DHIS2 and goal-oriented education sector stakeholders in The Gambia. The following subsections relate to the case descriptions in subsection 4.2.

Educational Decision-Making. Extant IS literature points out how affordances are interdependent and that the actualization of one affordance can cause other affordances to emerge (e.g., [3, 16, 19]). Data-driven decision-making depends on the actualization of lower- and mid-level affordances. DHIS2 affords the possibility of *configuring dashboards and analysis tools*. A user can thus have a personalized dashboard layout presenting the data, indicators, and analysis of most interest and relevance. The configured dashboards and analysis tools afford the user the possibility of *visualizing and inspecting educational data* from the user's own level and related sublevels. The user can – usually in collaboration with others – *take informed decisions* regarding a school, a school cluster, a region, or the entire country. Figure 5 illustrates how the actualization of the lower-level affordance *configuring dashboards and analysis tools* leads to the emergence of the subsequent mid-level affordance *visualizing and inspecting education data* and the higher-level, more abstract, affordance *informed decision-making*. The arrows in the figure indicate causal-temporal dependencies.

For instance, it is a prerequisite for the *informed decision-making* affordance that the two preceding affordances have been actualized.

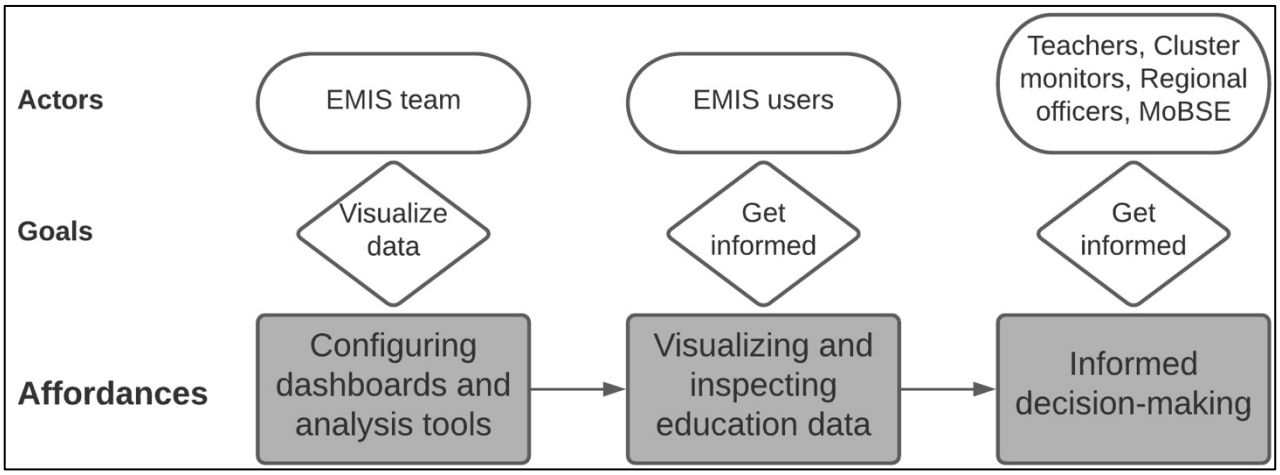

Figure 5. Decision-making affordances

Decomposing goals. Use of the DHIS2 Tracker module affords the possibility of *recording data on individuals.* When the EMIS contains individual data, teachers are afforded the possibility of *intervening in individual learner trajectories*. By following up the learners individually they enhance the possibility of *ensuring equal access to quality* education. Figure 6 illustrates how the actualization of the lower-level *recording data on individuals* affordance enables the mid-level affordance *intervening in individual trajectories* and the higher-level affordance *ensuring equal access to quality education*.

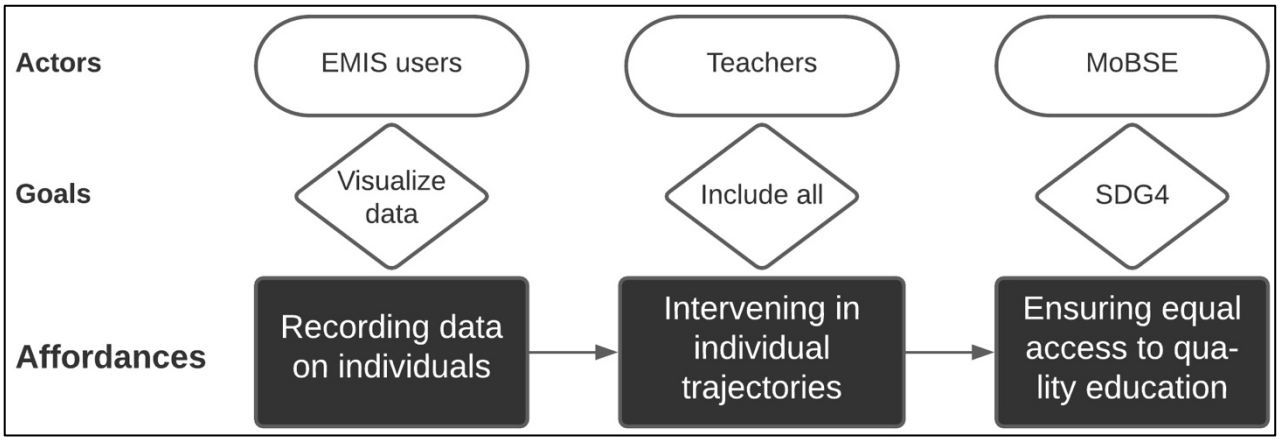

Figure 6. Data disaggregation affordances

The *ensuring equal access to quality education* affordance can also be considered an ensemble affordance, as it both is dependent on and consists of the two preceding affordances of *recording data on individuals* and *intervening in individual trajectories* (Figure 7). The affordance *ensuring equal access to quality education* cannot be actualized unless the two preceding affordances *recording data on individuals* and *intervening in individual trajectories* have been actualized. At the same time, *ensuring equal access to quality education* consists of the composite of the preceding affordances, as illustrated in Figure 7.

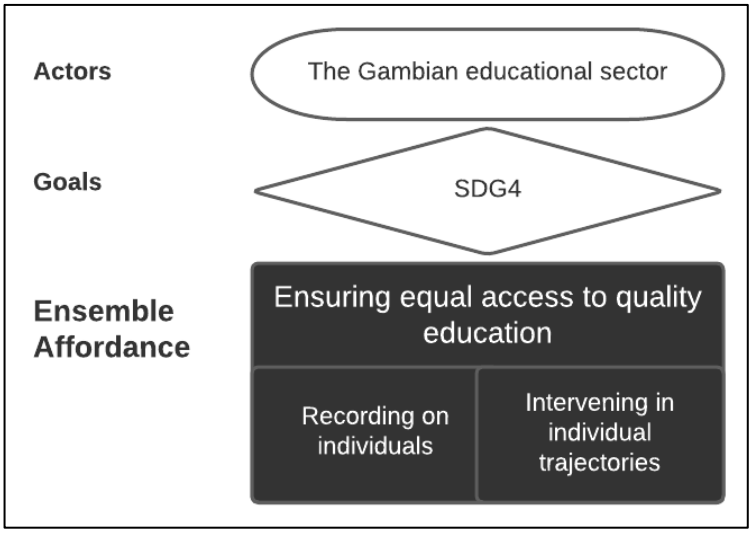

Figure 7. Higher-level disaggregation affordance

Decentralizing Data Access – a Goal or an Affordance? Thapa and Sein [19] explain how multiple affordances can form an ensemble of affordances which together can be actualized in order to reach the ultimate goal. However, as pointed out by Volkoff and Strong [25], it can be difficult to distinguish an abstract affordance from the desired outcome (i.e., the goal). But does the goal necessarily have to be different from the affordance? Consider the digitized Gambian SRC. Figure 8 illustrates how the actualization of the *developing addon* affordance is a prerequisite for the *integrating addon* affordance. And once integrated, trained users can start *accessing the data* provided through the SRC app. There are of course other affordances at play, such as *quality data collecting* and *timely data inputting,* which are also necessary for the *accessing data* affordance to emerge. The underlying affordances that constitute a higher-level affordance may need to be identified and examined whenever there is a breakdown or failure to realize the higher-level IT affordance. This is for example the case when stakeholders at the school level provide feedback that the available data is erroneous or misrepresents local reality. In this case, it is necessary to consider the *collecting data* affordance.

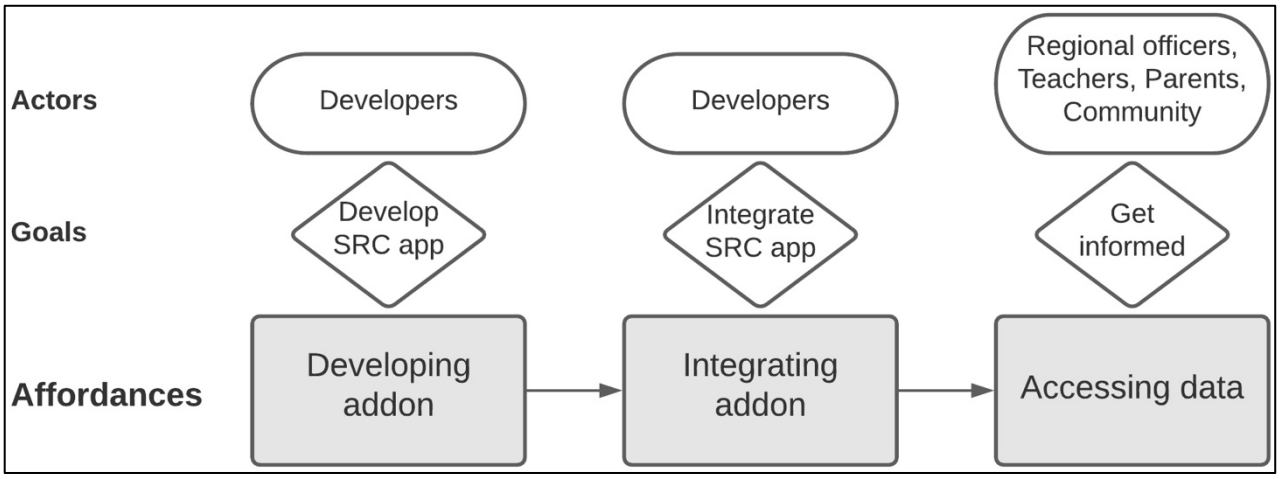

Figure 8. SRC lower-level affordances

The three singular affordances illustrated in Figure 8 form the composite affordance of *decentralizing data access* (Figure 9). Just as Shaw and Bransford's [38, p. 42] example of the *eating* affordance being an ensemble of the biting, chewing and swallowing affordances, the *decentralizing data access* affordance is composed from the *developing addon*, *integrating addon* and *accessing data* affordances. While the singular affordances are lower-level technology use-affordances, the ensemble affordance is a mid-level affordance, which requires action from several actors to be actualized.

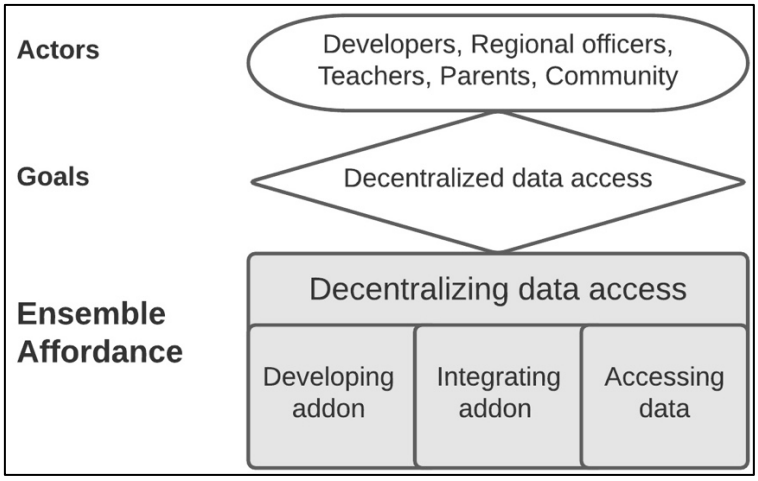

Figure 9. SRC higher-level ensemble affordance

Through actualizing the three lower-level affordances, the *decentralizing data access* affordance is also actualized, and the "immediate concrete outcome" [16, p. 69] is decentralized data access, allowing local stakeholders to access data previously unavailable to them. In this case, the goal and outcome are somewhat indistinguishable from the affordance itself.

Extending the Conceptual Framework. In the framework derived from Gaver's [26] affordances, as illustrated in Figure 2, sub-affordance n_1 and sub-affordance n_2 are actualized simultaneously (e.g., in Gaver's example, the human pulls the door while pulling the door handle). However, this is not necessarily the case. The findings in the preceding subsections show that a composite affordance can also consist of sequential sub-affordances, as indicated by Shaw and Bransford's eating affordance [38, p. 42]. For instance, the *ensuring equal access to quality education* affordance is a composite of the sequential affordances *recording on individuals* and *intervening in individual trajectories* (see Figure 7). Thus, we have extended the conceptual framework we derived from Gaver's affordances to include sequential affordances in a composite affordance. In Figure 10 the affordance *m* consists of three other affordances, one of which is also a composite affordance (n).

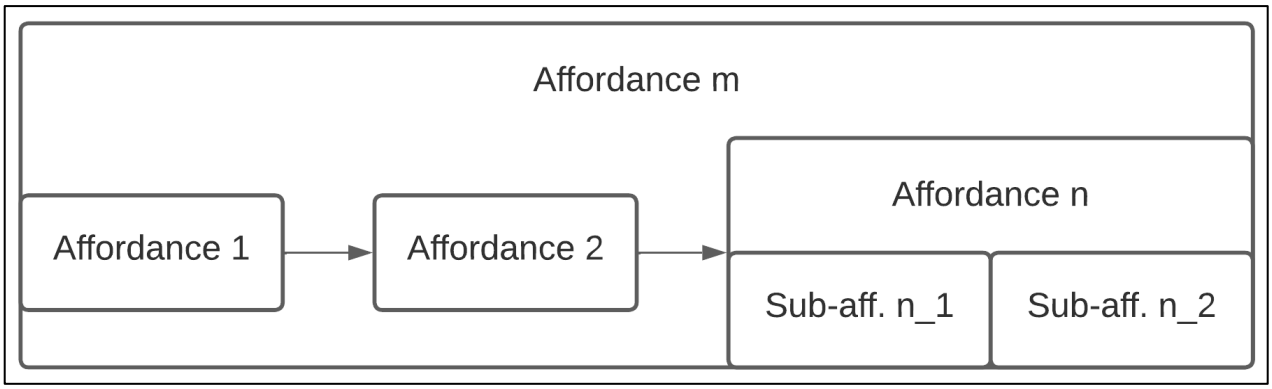

Figure 10. Our extended conceptual framework

5.3. Choosing the Appropriate Level of Granularity

As seen from the Gambian examples, the design and use flexibility of the DHIS2 platform, matched with local capacity strengthening in both software configuration and data analysis, opens an array of action possibilities. However, it is not the direct technology use, exemplified by the lower-level affordances in this paper (e.g., developing and integrating addons, accessing data, recording data on individuals), that are the key affordances to understand. These lower-level affordances resemble the technology functionalities themselves and might appear indistinguishable from the functionalities. However, just as a knife affords humans the very basic cutting affordance [22, pp. 133, 137], developing addon, integrating addon, and accessing data should also be considered affordances. What we should be concerned with, is what use of technology in context affords, that is, what mid- and higher-level affordances emerge from the actualization of lower-level affordances to address real world problems. The mid- and higher-level affordances identified in our case are *decentralizing data access*, *intervening in individual trajectories, ensuring equal access to quality education, visualizing and inspecting education data,* and *informed decision-making*.

5.4. Defining Granularity Levels

While technology certainly offers an opportunity for development, it is not a panacea for development [7, p. 12]. Our intention is not to say that technology drives development outcomes at a societal level, such as equitable access to

education. Rather, our analysis highlights how mid- and higher-level affordances are composed from lower-level affordances. Hence, an understanding of affordances as action possibilities that are interdependent both temporally (sequence of affordances) and spatially (composite affordances) [3, 16, 19, 26] is necessary to understand when, in what way and for whom higher-level affordances become actualized, or not. Scholars studying IT affordances tend to distinguish between lower-level affordances (typically basic technology use) and abstract higher-level affordances emerging from lower-level affordances. However, in many cases, such as in the cases presented here, it is more revealing to identify and study the actualization of *mid-level* affordances.

5.5. Mid-Level Affordances

Mid-level affordances are affordances on a granularity level between lower-level technology use affordances and abstract higher-level affordances. Similar to higher-level affordances, mid-level affordances do not denote direct technology use. However, we argue that they are more directly related to organizations' technology use than the abstract higher-level affordances. Mid-level affordances emerge directly as a result of actualization of lower-level affordances in organizational contexts. Figure 11 illustrates how the affordances identified through the Gambian DHIS2-EMIS case study relate to the three granularity levels we have outlined. Mid-level IT affordances can be thought of as the perceived and realized action possibilities of what is often associated with organizational "IT capabilities" (e.g., [39-40]) and in many studies are left as a black box.

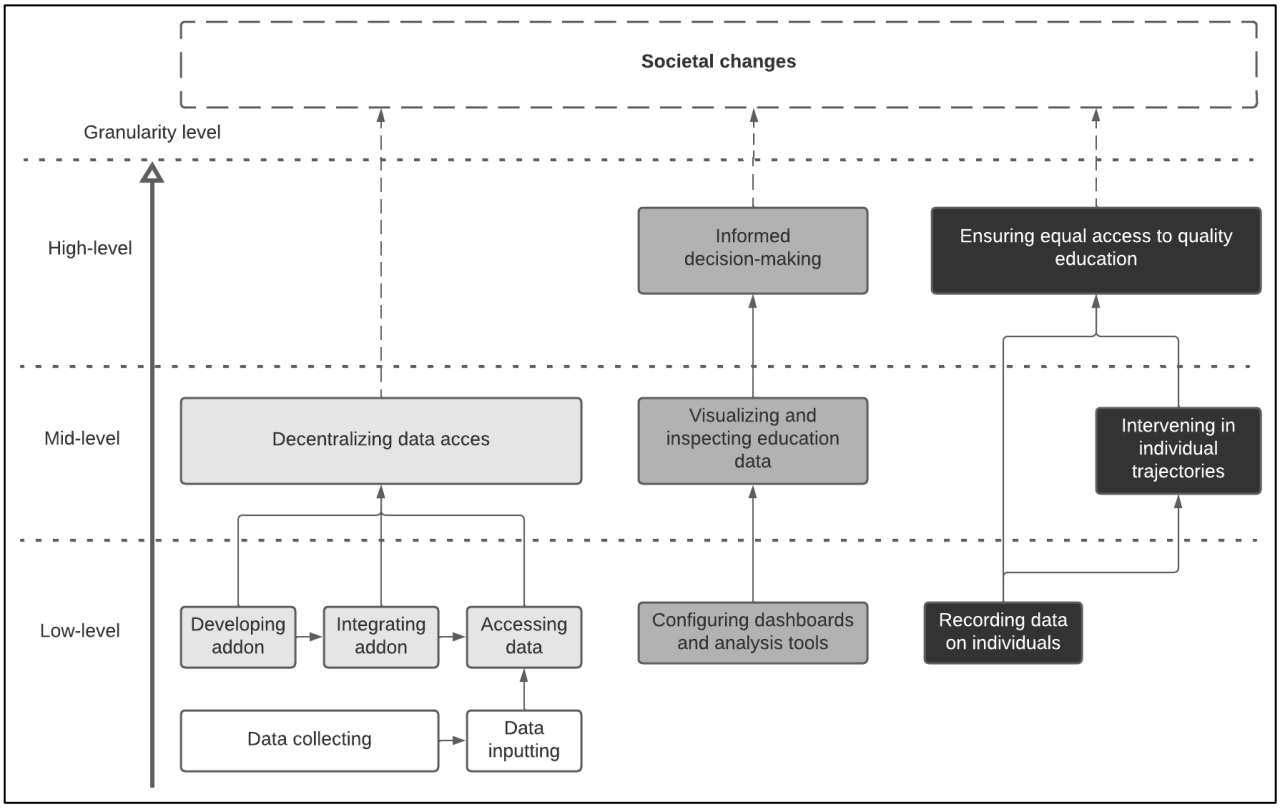

Figure 11. Lower-, mid-, and higher-level DHIS2-EMIS affordances

6. Conclusion

EMIS stakeholders strive to identify and scale (desirable) action possibilities that may be actualized to produce value in local context. The actualization of the action possibilities in any local setting relies on a conducive interplay between technology, the capability of the enacting actor, and goal-oriented action. Both the affordance and the actor can be composites, in the sense that an affordance can emerge from an ensemble of lower-level affordances (e.g., the affordances *developing addon*, *integrating addon*, and *accessing data* constitute the *decentralizing data access* affordance), while enacting actors can be an individual, a group of individuals, an organization or a social movement with a shared aspiration. For practitioners, this means that higher-level shared goals (outcomes), such as the SDG4, needs to be aligned with contextual conditions as well as affordances that can be actualized in those contexts. When desirable affordances are not actualized, we can start to unpack the ensemble affordance to identify constitutive affordances that need to be actualized.

We believe a composite affordance perspective, which recognizes temporal and spatial interdependencies of IT affordances, is useful in bridging what we perceive to be a growing policy-practice divide in the education sector in low-income countries. International agendas, such as the SDGs put pressure on public sector services to produce an

increasing amount of granular data, while the underlying structures that should produce and act on the data are not strengthened proportionately. Often, top-down and technology deterministic policy goals tend to inform too much emphasis on the lower-level affordances of technology use, such as enabling data collection and international reporting. These lower-level affordances are then expected to enable strides towards the actualization of lofty higher-level IT affordances such as ensuring equitable education, which in turn lie the foundation for societal development. However, this introduces the risk of underestimating the complexity and interdependency of mid-level organizational IT affordances. These affordances, often black-boxed in literature as organizational IT capabilities, are realized from a combination of lower-level affordances and are prerequisite to the actualization of higher-level affordances. Mid-level IT affordances, such as the ones identified in our case study, must be actualized across heterogenous socio-technical and political context to produce significant strides towards development outcomes at a societal level.

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