
Title	Integrating distributed with ecological leadership: Through the lens of activity theory
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Integrating Distributed with Ecological Leadership: Through the Lens of Activity Theory

Purpose: Leadership for the implementation of an educational innovation in Singapore was examined by integrating distributed leadership with an ecological perspective of leadership and analysed using the third generation of cultural-historical activity theory (CHAT).

Research Method: The study adopted the naturalistic inquiry approach of a case study of a cluster of six elementary schools in the process of diffusing an educational innovation over one academic year. The research team observed six open classroom sessions and two review sessions at the cluster level. A total of two Ministry officers, one Master Teacher, ten school leaders, twelve key personnel and twenty-one teachers were interviewed.

Findings: The use of CHAT as an analytical lens provided insights into how different activity systems at the ministry, cluster, and school levels interact in providing leadership for the implementation of the innovation, the tools utilised, the rules/norms which enabled or constrained the innovation's implementation, and the evolving nature of the leadership provided. The study affirms the value of incorporating an integrative perspective in the analysis of leadership and the value of CHAT in unpacking the distribution of leadership across interrelated activity systems, and in highlighting the temporal evolutionary nature of leadership.

Introduction

Attempts to implement and sustain changes in teachers' instructional practice in schools have always been fraught with difficulties, particularly when the approach is perceived by teachers to be top down and with little say on their part (Boylan, 2016; Evans, 2016; Hung et al., 2019b). Different solutions have been suggested, including leading from the middle, with the middle interpreted differently depending on one's perspective

(Lipscombe et al., 2020; Ho et al., 2020; Fullan, 2015), and the promotion of teacher leadership (Boylan, 2018; Gumus et al., 2018; Hung et al., 2018a; Scribner and Bradley-Levine, 2010). Both leading from the middle and teacher leadership have often been positioned under the umbrella of distributed leadership (Lipscombe et al., 2020; Ho et al., 2020; Kelley and Dikkers, 2016; Liu, 2020; Klar et al., 2016).

Concurring that leadership practice would benefit from being studied from an integrative perspective (de Jong et al., 2020; Daniëls et al., 2019; Bush, 2003), leadership for the implementation of an educational innovation was examined by integrating distributed leadership with an ecological perspective of leadership, and analysed using the third generation of cultural-historical activity theory (CHAT). The main research question was “How was leadership distributed in the implementation of an educational innovation across and within schools?”

An ecological understanding of leadership is particularly pertinent in the context of Singapore’s education system, which functions in a paradoxically centralised and decentralised manner (Ng, 2017; Tan and Ng, 2007). While the Ministry of Education (MOE) sets the education policies which schools are expected to implement, these are generally broad policies which schools are encouraged to customise and to innovate in their local implementations. Over time, Teh, Hogan and Dimmock (2013) observed a shift in Singapore towards a significant decentralisation of pedagogical authority to individual schools.

Between the macro level of MOE and the meso level of schools, this centralised decentralisation approach is reinforced by the exo level cluster structure, which serves the dual purpose of ensuring schools align with MOE’s overall direction while supporting and funding individual school innovations (Lee et al., 2020). The cluster structure is a mix of hierarchical steering and the more decentralised structure of network governance and

collaboration (Lee et al., 2020). In 2021, there are 28 clusters, led by Superintendents, who were previously school principals, with 12 to 13 schools catering to grades 1 to 12 in each cluster.

In such a nested educational ecological system, efforts to diffuse an educational innovation, especially if initiated at the ministry level, would need to involve the various levels, moving from macro (ministry) to exo (cluster) and to school/department (meso), before moving finally to teachers at the classroom level (micro). This means that multiple levels of leaders are required to navigate the interacting levels of the ecological system in order to leverage collective social capital and resources and achieve alignments (Hung et al., 2016). The research question was asked in the context of a cluster's attempt to diffuse an educational innovation, which originated at the ministry level, to the primary schools within the cluster. The intent was to examine how leadership was distributed across the ecological levels in supporting the diffusion of this innovation.

Literature Review

This section provides a review of distributed leadership and an ecological perspective of leadership, highlighting similarities between the two constructs which support their integration, and suggesting key differences which provide value add when the two constructs are integrated. CHAT and its links to distributed leadership and the implementation of innovations are also explained.

An Ecological Perspective of Leadership

An ecological perspective of leadership views leadership as a process emerging from interactions between leaders and followers as they mutually engage in problems to achieve a shared vision. In an ecological perspective, the ecological context and its social cultural environment is more important than individual leaders (Harms and Leise, 2011; Wielkiewicz

and Stelzner, 2005); expressed simply, leadership is a process which is inclusive of its context (Wielkiewicz and Stelzner, 2007, September).

Although Wielkiewicz and Stelzner (2005) do not allude directly to the distribution of leadership, they note that the ability to influence decisions is distributed amongst organisation members. Leadership as an influence process to achieve desired goals is a broad definition generally accepted in the literature (Connolly et al., 2019; Daniëls et al., 2019; Leithwood et al., 2020). In explaining their concept of ecological leadership, Toh, Jamaludin, Hung and Chua (2014) observed that ecological leadership need not reside in individuals. Instead, ecological leadership can be “collectively achieved by augmenting the collective capacities of actors in the ecology” (pp. 847), again alluding to the distribution of leadership.

In a book on “Innovations in educational change: Cultivating ecologies for schools”, Hung and associates (2019b) explicitly linked the diffusion and sustaining of educational innovations to ecological contexts, viewing contexts as integral to the process of implementing innovations in schools, which are situated within the nested context of ecological systems. Hung and associates argue that initiatives to introduce innovations in schools need to consider interactions and tensions amongst ecological subparts of the system, which include the following: macro (e.g. the Ministry of Education), exo (e.g. a cluster of schools), meso (the school itself), and micro (the teachers in the classroom). The editors propose the importance of ecological leadership, which they view as different from distributed leadership in that the latter is enacted within a specific level of the ecology, usually a school, rather than across ecological levels (Hung et al., 2019a).

Distributed Leadership

We subscribe to Spillane’s and associates’ definition of distributed leadership, which views leadership as distributed in two senses: leader-plus and leadership practice (Spillane et

al., 2008; Spillane, 2006). The leader-plus perspective recognises that leading schools involve multiple individuals. In most studies on distributed leadership, as suggested by Hung and associates (2019a), these individuals are usually within the ecological level of the school (Tay and Lim, 2016; Ng and Ho, 2012; Liljenberg, 2015; Diamond and Spillane, 2016; Bush and Glover, 2012).

The leadership practice perspective highlights the critical role of the context, in which the context is “both constitutive of and constituted in leadership activity” (Spillane et al., 2004: 21). This means that the context shapes leadership activities, but the context may also be created or transformed through leadership activities, thus blurring the boundary between leadership and the context in which the leadership is enacted. Although it is suggested that leadership has greater influence when it is widely distributed (Leithwood et al., 2020), the main context in most studies is the internal school environment and community (Al-Harathi and Al-Mahdy, 2017; Angelle, 2010; Bush and Glover, 2012).

In a 2016 retrospective review of distributed leadership, Diamond and Spillane (2016) emphasise the importance of examining how leadership practice is achieved by people interacting with one another and their situations (contexts) in schools, school systems and communities. Referring to Diamond and Spillane (2016), Larsson and Lowstedt (2020) observe that the situational dimension of distributed leadership has been relatively neglected in leadership research, and argue for the need to focus on how organisational structures, activities and cultural-cognitive beliefs shape and are shaped by social interactions.

An Integration of Ecological Leadership and Distributed Leadership

Our study includes analysis of leadership practice by stakeholders beyond schools, consistent with an ecological perspective of leadership in which organisations are open systems and influence one another. In proposing an integration of distributed leadership with

an ecological perspective of leadership, we suggest that context is not just within a school setting but beyond (the practice dimension) and leaders are also not just within a school but beyond (the leader-plus dimension). Table 1 highlights the similarities in the two leadership constructs, which support our argument for an integration of the two constructs.

Table 1: Comparison of distributed leadership and ecological leadership

Distributed Leadership (Vennebo and Ottensen, 2012; Spillane, 2006; Spillane et al., 2001)	Ecological Leadership (Harms and Leise, 2011; Wielkiewicz and Stelzner, 2005; Toh et al., 2014)
<ul style="list-style-type: none"> • Leadership is emergent 	<ul style="list-style-type: none"> • Leadership is an emergent process which arises from the actions and interactions of individuals
<ul style="list-style-type: none"> • Openness of boundaries 	<ul style="list-style-type: none"> • Organisations are open systems
<ul style="list-style-type: none"> • Expertise is distributed 	<ul style="list-style-type: none"> • Expertise is scattered throughout an organisation
<ul style="list-style-type: none"> • Leadership practice is stretched across leaders, followers and situations • Leadership is an interactional process that is socially and culturally situated 	<ul style="list-style-type: none"> • Leadership emerges from interactions between leaders and followers, in constantly changing patterns depending on the contexts • Leadership process is inclusive of its context.

Cultural-Historical Activity Theory

One distinctive element of distributed leadership is that it is rooted in CHAT, in which leadership practice is perceived as embedded in collectively organised, artefact mediated activity systems (Spillane et al., 2004; Gronn, 2002a; Liu, 2020). Although ecological leadership is not explicitly linked to CHAT, it has conceptual similarities with distributed leadership, particularly the concept that ecological leadership is constituted in leadership enactments in situ. Thus, we propose that using activity theory as an analytical lens for an integrated distributed and ecological leadership perspective can help to illuminate

the situational and emergent dimensions of leadership. Leadership is not just stretched over people (Diamond and Spillane, 2016), it can also be stretched over different contexts or activity systems, and over time.

In this section, we briefly present CHAT and its link to educational innovations as well as distributed leadership. In brief, in CHAT, human activities take place within an activity system, with the motivation to transform some object or person (Engestrom, 2004). The relations between subject and object, which the subject desires to transform into an outcome, are not direct but are mediated by components in the activity system, namely the community, tools, rules, and division of labour (Engestrom, 1999), as illustrated in Figure 1.

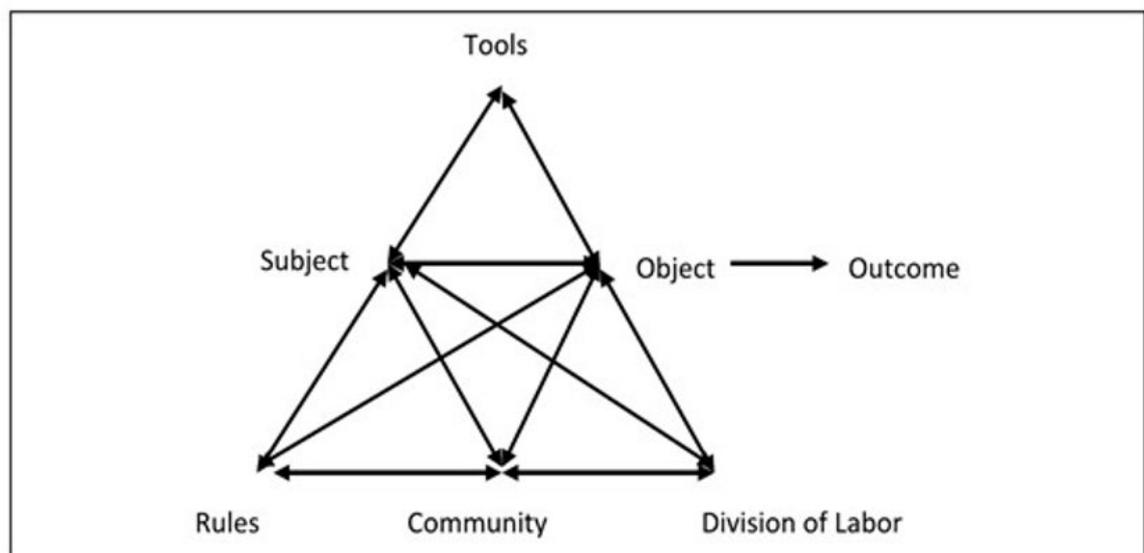


Figure 1. Model in Engestrom (1999).

Thus, in activity theory, the unit of analysis is the social, collective activity which is situated within a community-based context, similar to the concept that distributed leadership is a collective social process (Larsson and Löwstedt, 2020) and that the unit of analysis should be the leadership activity distributed over multiple leaders, followers and the situation (Spillane, 2005). Tools include material and psychological artifacts and can be physical,

cognitive or symbolic; rules include norms, policies or conventions of the community which can either enable or constrain actions and interactions; community refers to a community of actors who share a common object; while division of labour refers to both the division of tasks and the status relations between actors (Barab et al., 2002). In a study of leadership, the division of labour may refer to the leadership actions and interactions of multiple levels of leaders, horizontally amongst members of similar status or vertically amongst members with differences in power and status (Ho and Ng, 2017). In the third generation CHAT, it is proposed that the minimal model comprises two interacting activity systems with a partially shared object (Yamazumi, 2008), which we suggest in an education system includes schools and activity systems beyond schools.

CHAT and educational innovations. Engeström (2008), Sannino and Norcan (2008) used CHAT to study the diffusion and sustaining of educational innovations or school change, with change arising from interactions between multiple activity systems: within and between schools, or between schools and external organisations and communities. Sung, Lee and Choi (2016) used CHAT to study efforts to change pedagogical practices in a school in South Korea while Yamazumi (2008) used CHAT to analyse a hybrid after-school learning activity for children based on a partnership between a university and local elementary schools.

CHAT and Leadership. Vennebo and Ottensen (2012) noted that though CHAT has been used to study innovative work, it has rarely been used to study how leadership emerges. Despite Gronn's (2002b) suggestion to use CHAT as a theoretical framework to study jointly performed leadership activity and acknowledgement that distributed leadership has its theoretical roots in activity theory (Spillane et al., 2004), empirical studies on distributed leadership have rarely used CHAT as an interpretive lens (Ho and Ng, 2017; Hartley, 2010).

Ho, Chen and Ng (2016) examined distributed leadership for a school ICT reform through the lens of activity theory. However, the focus was on leadership distribution within a school, though involving two activity systems, one at the school and one at the ICT innovation level. Similarly, a study by Tay and Lim (2016) which applied activity theory to analyse distributed leadership for one-to-one computing was within the context of one elementary school, though it surfaced leadership by various stakeholders, including the school principal, the ICT coordinator, curriculum co-ordinators and teachers, suggesting the involvement of different activity systems within the school. Hirsh and Segolsson (2019) applied activity theory to examine the involvement of teacher leaders in improving the quality of instruction in a school, with the conclusion that leadership practice was effectively stretched between the principal and teacher leaders. Recently, Vennebo and Aas (2020) conducted a study on school change processes, and how school leaders made sense of and responded to tensions arising from the change effort, informed by CHAT as a theoretical lens. Once again, the focus was on leadership within the school.

Methodology

The purpose of this study was to examine leadership for the implementation of an educational innovation, Archimedes, in a cluster of six schools. An integrative perspective of distributed and ecological leadership was adopted, with the use of the third generation of CHAT as an analytical lens to explore how activity systems at different ecological levels (school, cluster, and the ministry) interacted and provided leadership for the educational innovation. The main research question was “How was leadership distributed in the implementation of an educational innovation across and within schools?”. The study was approved by an Institutional Review Board (IRB reference: 2018-12-021-01) before data was collected.

The research design adopted is the qualitative case study, which Merriam (1998) suggests is useful to yield an in-depth understanding of the situation when the focus is “in the process rather than outcomes, in context rather than specific variable, in discovery rather than confirmation” (p. 19). The focus of distributed leadership and ecological leadership is on leadership as a dynamic and collective social process (Liu, 2020; Larsson and Löwstedt, 2020; Harms and Leise, 2011), and both leadership constructs view contexts as fundamental to the enactment of leadership (Wielkiewicz and Stelzner, 2005; Spillane et al., 2004). Indeed, the context is both “constitutive *of* and constituted *in* leadership activity” (Spillane et al., 2004, p 21, italics in original), meaning that the boundaries between the phenomenon studied (leadership) and the context are not clear. Yin (2003) proposes that a case study is an appropriate research design in such a complex situation, when it is not clear when the phenomenon ends and the context begins or vice versa.

Data Collection

Based on the two main types of case studies identified by Stake (1995), instrumental and intrinsic, the approach selected for this research was the instrumental case study, as selection of the case was deliberate to answer specific research questions. The aim of the case study was to provide insight into how leadership was distributed in the implementation of an educational innovation across and within schools.

The case selected was a cluster which was in the process of implementing a mathematics innovation, Archimedes, developed by the Ministry of Education (MOE), to six elementary schools in the cluster, over a period of one year. Of the six schools, four were not required by MOE to implement the innovation, which was intended to help schools with pupils with weak performance in mathematics. The initiative to promote Archimedes in the

cluster was by the Cluster Superintendent (Supt). The Supt appointed a lead school to oversee the Archimedes cluster community.

This cluster was selected for two reasons. First, since the study was interested in the distribution of leadership across ecological levels, this case was chosen as it could potentially provide insight into leadership at the ministry (macro), cluster (exo), school (meso) and teacher (micro) levels. Although all clusters support schools in implementing MOE policies, the promotion of Archimedes was interesting in that it was not mandatory for all schools to adopt Archimedes, suggesting a greater need for leadership at both the cluster and school levels to persuade teachers to adopt the innovation. Second, it is generally more difficult to get access to clusters and to schools in the cluster, compared to getting access to individual schools. In this case, the Supt provided consent for the cluster level observations, as did all six schools involved, although only four of the six schools agreed to participate in the school-level interviews and focus group discussions.

At the macro ministry level, two curriculum officers in the mathematics division who were involved in the development and roll out of Archimedes, and a Master Teacher who supported the cluster were interviewed. At the exo cluster level, where selected teachers from the six schools participated in a cluster community, seven of eight open classroom sessions (lesson observation followed by post-lesson debrief discussion) and two review sessions were observed. At the meso school and micro teacher levels, four of the six schools, including the lead school, agreed to participate in the study, which involved researchers interviewing the relevant school leaders, the head of the mathematics department (HOD), level heads (LH), senior teachers (ST) and teachers who participated in the cluster community from 2018 to 2019. Table 2 provides a summary of the contexts and the individuals involved.

Table 2: Schools and teachers involved in the Archimedes cluster community in 2018-2019

Schools	School A	School B	School C	School D	School E	School F
Brief Contexts	Year 2 participating in the community	Year 3 Lead school Not an official Archimedes school But received training from MOE	Year 3 Official Archimedes school	Year 1 School left the cluster end of 2018 but continued in community Not an official Archimedes school	Year 3 Official Archimedes school	Year 1 New school in cluster in 2019 Not an official Archimedes school
School Leaders	1 P, 1 VP	1 P, 1 VP	1 P, 2 VP	1 VP	1 P	1 P
Key Personnel	1 ST (2018), 2 LH	1 HOD, 1 EMM	1 HOD, 1 CMM	1 HOD	1 HOD, 1 ST (2018)	1 HOD, 1 LH
Teachers	Tr 1 (2018), Tr 2, Tr 3	Tr 1, Tr 2, Tr 3, Tr 4, Tr 5, Tr 6	Tr 1 (2018), Tr 2, Tr 3 (2018), Tr 4	Tr 1, Tr 2	Tr 1, Tr 2, Tr 3	Tr 1, Tr 2

Observations of the cluster sessions enabled the researchers to observe leadership in action, while the interviews/FGDs enabled the researchers to discuss with identified leaders their leadership actions, as well as to discuss with stakeholders who they perceived as providing leadership and the kind of leadership provided. Gunter(2001) notes that such an approach enables the “interplay between what is said is done and what is experienced as being done” (p. 59).

Three researchers were involved in the observations, interviews, focus group discussions (FGD), and data analysis, with at least two researchers taking detailed fieldnotes at the cluster community sessions. Interviews and FGDs were conducted by at least two researchers, and involved semi-structured interviews, with interview questions customised

based on the different roles and contexts of the participants and conducted after observations of the cluster sessions had been completed. Samples are provided below:

- a) School principal/vice-principal: How did you decide to involve your school in this cluster effort? What do you see as the role of your school?
- b) Mathematics HODs: What do you see as the role of your department in this cluster effort? How did you select the teachers to participate in this cluster effort?
- c) Lead HOD: How did you work with the lead school's Mathematics HOD? What do you see as your role as a facilitator of the debrief sessions?
- d) Teachers who conducted the open classroom sessions: How were you supported in designing the lesson? How did you feel about the lesson observation and debrief experience?

All interviews and FGDs were audiotaped and transcribed, except for three interviews where the interviewees requested not to be audiotaped. For these interviews, field notes were taken by two researchers to capture the content as verbatim as possible. All transcribing was done by one of two researchers, enabling them to have intimate knowledge of the data.

Data Analysis

The three researchers independently analysed each field note and transcript, adopting a grounded approach and line-by-line analysis (Charmaz, 2006). Analysis was discussed through monthly meetings to gain group consensus (Saldaña, 2016). Each school was analysed as a within-case analysis, followed by a cross-case analysis to check if identified themes applied across cases or there were disconfirming evidence (Huberman and Miles, 1994; Creswell, 1998). The cluster activities were also analysed as a case (or activity system) by itself, which interacted with the school activity systems.

Since leadership is emergent and dynamic, researchers did not want to constrain the analysis by beginning with a predetermined list of codes. However, the intent to analyse the distribution of leadership across ecological levels meant that the researchers were sensitised to look out for leadership actions or evidence of influence by stakeholders at various ecological levels, including ministry officials, the Supt, school leaders, key personnel and teachers. This constituted the first level of analysis. From this first level of analysis, the following themes emerged: clarity and confluence of purpose across the ecological levels, supportive leaders, structures and cultures, promotion of teacher ownership of the innovation, evidence of customisation and integration of the innovation, and evidence of planning such as in the rotation of teachers to participate in the cluster community.

The use of CHAT as an analytical lens constituted a second level of analysis, with researchers re-examining the data and the initially generated themes for cultural, social and structural tools or norms, and re-examining the division of labour amongst the various stakeholders found in the first level of analysis to be practising leadership. For the study, division of labour in activity theory is interpreted as the distribution of leadership actions amongst multiple people (Ho et al., 2016), corresponding to the concept of leadership practices being “stretched” over various people (Spillane et al., 2004, p. 16).

Table 3 provides an example of how selected data regarding leadership provided at the cluster level was analysed using CHAT:

Table 3: Using CHAT as an analytical lens

Data	CHAT as analytical lens
Supt “selling” the innovation at cluster meetings (VP1, School C)	Division of labour: Supt initiated and pushed for the community

<p>Our Supt “got the primary schools together and he broached the idea” (P, School C)</p> <p>“It [the innovation idea] started from cluster, that means started from Supt” (P, School B)</p>	
<p>“The first structure is that we actually put aside time for our teachers” (P, School C)</p> <p>“Supt...made every body fix a date” for the cluster community to meet (P, School B)</p>	<p>Tool: provision of time (cluster level)</p> <p>But also indication of school leaders’ support at school level (division of labour)</p>
<p>The principal of school B confirmed that the Supt initiated the meeting with the curriculum division in the ministry</p>	<p>Rule/norm: The Supt was able to bring in MOE expertise because the cluster is designed to be a link between MOE and schools</p>

Findings

In the third generation CHAT, it is proposed that the minimal model comprises two interacting activity systems with a partially shared object (Yamazumi, 2008). The study found three main interacting activity systems, with a shared object, represented in Figure 2, with details elaborated in the article and summarised later in this article in Figure 3.

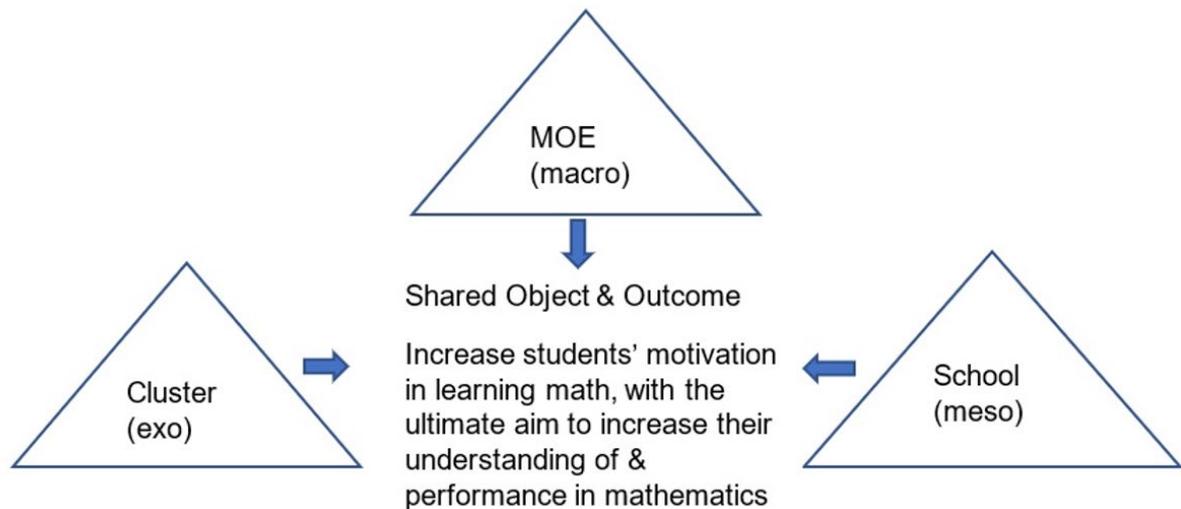


Figure 2: Leadership distribution and interactions across three activity systems

Leadership at the Ministry (Macro) Level

Although the idea to promote Archimedes to the elementary schools in the cluster originated with the Supt, it can be argued that MOE provided leadership by designing the Archimedes programme and promoting its use in selected schools. The full programme included training by the Ministry for mentors and teachers, a lesson plan template, a mentor-mentee structure, lesson planning and implementation by mentees, and lesson debrief between mentor and mentee.

The programme was designed and driven by the curriculum planning and development division (CPDD), with training provided by CPDD and Master Teachers from the Academy of Singapore Teachers (AST), who also served as external mathematics mentors. This **division of labour** between the two ministry divisions was further supported by the training of cluster-based mathematics mentors, which helped to distribute expertise to be more accessible to schools, since the cluster structure serves as a link between the Ministry and schools (Ho and Koh, 2017).

Leadership at the Cluster (Exo) Level

Leadership was exhibited first and foremost by the Supt who initiated the Archimedes cluster community and appointed a school to lead that community. The cluster community served as the main **tool** to develop the cluster teachers and support their use of Archimedes, through providing opportunities for teachers to learn from heterogenous peers and the development of collective social capital. As teacher 1 from school D shared, “The community is more of learning from one another...through the lesson observation, it’s like “Oh, this is another way I can do which I can bring back to my class”.

Tapping his position as Supt and the **norm** of the cluster serving as a link between the Ministry and the schools, the superintendent persuaded the ministry to train the lead school, even though the lead school was not in the ministry’s list of schools who had to adopt Archimedes. The cluster structure served as a **tool** enabling the Supt to lead from the middle (Fullan, 2015), connecting MOE (macro level) and the schools (meso level).

The Ministry’s training of the lead school enabled its HOD to lead the Archimedes cluster community, supported by the cluster math mentor and a Master Teacher as a knowledgeable other, “our consultant” (HOD, school B, Oct session). Adapted Archimedes structures served as **tools** to guide the community’s interactions and learning, including a pre-lesson planning session using the Ministry’s designed lesson plan template, open classroom lessons, and post lesson observation debriefs.

Other **tools** designed to develop the teachers’ competency in implementing Archimedes included the deliberate rotation of teachers to plan and conduct the open classroom lessons, and the schools’ provision of time for the teachers participate in the community. The provision of a common time by the six schools was engineered by the Supt who shared that he “engaged school leaders two years back so they can prepare” (Supt, Sep review session) to

free up this time. That this provision of time was critical to the teachers is seen in a teacher's observation that the "blocking out that period of time... is already very helpful... a good, humane part" (Tr 3, school A).

There was clearly **division of labour**, or the distribution of leadership; some were deliberate and designed, supported by a high-power distance culture in Singapore (Goh, 2009), while others were more informal or spontaneous. For instance, the Supt had to step in to get school leaders to agree on a common meeting day and timing for the community. As the principal of the lead school explained, "Principal to principal, it's very difficult, to go and fix [a] date" (principal, school B,); the Supt had to mediate and be "the one who chair the meeting and, and make everybody fix a date". However, once the dates were settled, it was the principals who scheduled the time for their teachers to participate in the community. In addition, five principals and vice-principals provided support through their physical presence, dropping by the community's sessions to observe the open classrooms and or to sit in during the lesson debrief.

At the community sessions, the lead team and the Master Teacher facilitated the lesson debrief sessions, probing to elicit the teachers' pedagogical reasoning, providing suggestions on how to improve the lessons, and prompting the discussion of mathematical concepts, conceptual understanding as opposed to procedural knowledge, and mathematical language.

Teachers were 'cast' into leadership roles by virtue of them needing to design and conduct open classroom lessons, which were used as resources to 'train' their peers. The teachers showed leadership through their unique interpretation and implementation of Archimedes: School F's lesson (Tr 2) was designed to incorporate differentiated instruction, the school's focus, while other lessons highlighted the teachers' comfort level in using technology in their regular teaching (Tr 4, school C; Tr 2, school E).

Although debrief sessions were facilitated by the lead school's HOD, teachers participated actively in affirming the teacher conductor's positive practices (Feb session), sharing how they would have taught the topic (July session), raising issues for consideration, such as the use of accurate language in the teaching of mathematics (Feb and April sessions), or explaining why they would have not used a particular mathematics strategy such as the push out method for measuring perimeters (September session). Teachers contributed to creating a collegial culture at the debrief sessions, making the effort not to come across as judgmental, for example by referring to "we" instead of "you" when commenting on something the teacher conductor did which might have confused the students, thus conveying that the problem faced by the teacher conductor is one faced by many teachers (September session). One teacher conductor confirmed that she "did not feel intimidated" by the feedback given at her lesson's debrief (Tr 1, school C).

Regarding **norms**, the high-power distance culture inherent in Singapore's society enabled influence by persons perceived as having authority, like the Supt. Although the Master Teacher was able to provide instructional leadership because of her expertise, with teachers commenting that the Master Teacher "has more insights where we can tell the teachers what we should or should not do in class" (Tr 3, school F, Sep review session), her influence was also likely due to her perceived higher status.

However, the same high-power distance **norm** created some **tensions** between the Lead HOD and the teachers who planned the lessons. Although some teachers did not agree with the modifications suggested by the lead HOD, they "changed [their lessons] until really not your lesson" (Tr 2, school C). The tension was between teachers' autonomy as professionals, who have local knowledge of their students, and the lead HOD being perceived as a higher authority and possessing expertise in Archimedes as she was trained by MOE.

Leadership at the School Level

Since context is critical to both ecological and distributed leadership, each school's activity system differs, including in its interactions with the cluster's activity system. This article aggregates the findings across the four schools to present common findings on the tools, division of labour and norm components, based on cross-case analysis.

At the school level, the researchers observed the use of various **tools** to support the diffusion of the innovation. One critical **tool** was the selection and rotation of teachers to participate in the cluster community, with each school having different criteria for their selection, depending on their teacher profiles. For example, for school D, the school selected two teachers who taught students who were weaker in mathematics, the main target population for Archimedes, for easier transfer of learning by the teachers. These teachers could "test it out" and "have a feel" before they "see how can make it [Archimedes] possible for the other teachers" (Tr 1, school D). In School A, the teachers were selected more to level up their teaching competencies, as one teacher had previously taught students at grades 7 to 10, while another teacher had been teaching English instead of Mathematics for the past eight years. School A also deliberately rotated their teachers every one or two years to spread this cluster learning opportunity to more of their teachers. Thus, the selection and rotation strategy was not so much an attempt to delegate leadership for the innovation amongst the teachers, as in the division of labour, but more a tool to develop their teachers' competency in the teaching of mathematics.

Another strategy adopted by schools was the adaptation or integration of Archimedes to meet what they perceived as their schools' unique needs or contexts. The principal of the lead school (school B) was clear that she adopted Archimedes because she saw it as imparting "good teaching strategies" which can be applied to all student profiles, not just the low progress

learners that Archimedes was originally for. This made sense for the lead school since many of their students were high progress learners in mathematics. The HOD of School D observed that “School D’s Archimedes is very different from the other school’s Archimedes”, and that she was “doing a modified Archimedes to suit the needs of my school”, focusing initially on three of the eight principles undergirding Archimedes.

To encourage teachers to spend the time to explore the use of Archimedes, school leaders consistently communicated that they were not expecting immediate improvement in results. VP 2 in school C said that they were deliberately “moving away from a number game” and trusting teachers to know when and how to apply the innovation. We observed that there was indeed minimal school or department tracking of teachers’ use of Archimedes.

Division of labour within the schools was fairly standard, with school leaders and key personnel providing direction, support and resources. One principal shared he had to ‘push buttons’ if he wants something to be prioritised, and that he needs to provide leadership “to determine which direction this initiative is going to go” (school A). However, there were signs of instructional leadership provided by both officially assigned senior teachers and teachers who were assigned as Archimedes mentors. For example, a teacher in school B approached an Archimedes mentor for advice when she experienced problems implementing Archimedes with her high ability pupils. Teachers involved in the implementation of Archimedes shared that they actively customised their lessons to meet the needs of their students, spending more time on certain components of the lesson structure depending on their students. Thus, teachers were not passive recipients of the innovation, but were actively involved in making sense of it and adapting it for their lessons.

Enabling **norms** included existing department structures which enabled the mathematics department teachers to share what they learnt about Archimedes in department meetings, and

a generally collegial culture which also meant that teachers supported one another in implementing Archimedes. For example in schools B and C, teachers developed and shared Archimedes resources for each grade level. Teacher 2 in School B commented that she could openly disagree with her mentor, after which they would “just kiss and make up”. In general, the teachers indicated that their school cultures were “open to new approaches”, “welcoming and positive” (KP1 in school A), with school leaders having “a lot of trust in us” (Tr 3 in school B).

However, the **norm** of having to complete the syllabus and a relatively new Ministry ‘rule’ to minimise the amount of homework given to pupils meant that teachers felt pressured for time, especially since less homework for pupils meant more time is required during lessons for worksheets students usually complete at home. In addition, although teachers agreed that school leaders had communicated to them that results were not their immediate concern, teachers still expressed concern about results, citing parents’ expectations and their own hopes for their students to do well. Teachers experienced a tension between their agreement with the innovation’s objective to raise students’ motivation and confidence in learning mathematics and their conflicting needs to complete the syllabus and get results. Teachers expressed concerns that although Archimedes can help students to “retain better” and “understand better”, its implementation “takes time,...a lot of preparation, lots of time taken...to teach ”, which meant they “struggled to complete” the syllabus to be “on par with the other classes”, which to the teachers posed “quite a real problem” (Tr 2, school C). Teachers seemed to have resolved this tension themselves by deciding when, how often, and which aspects of Archimedes to implement in their regular lessons.

Interactions amongst the three activity systems

Figure 3 summarise the three activity systems, the main tools used, norms which enabled or constrained the leadership provided and the use of the innovation, and the division of labour. The double-sided arrows indicate key tensions felt and expressed by some of the teachers.

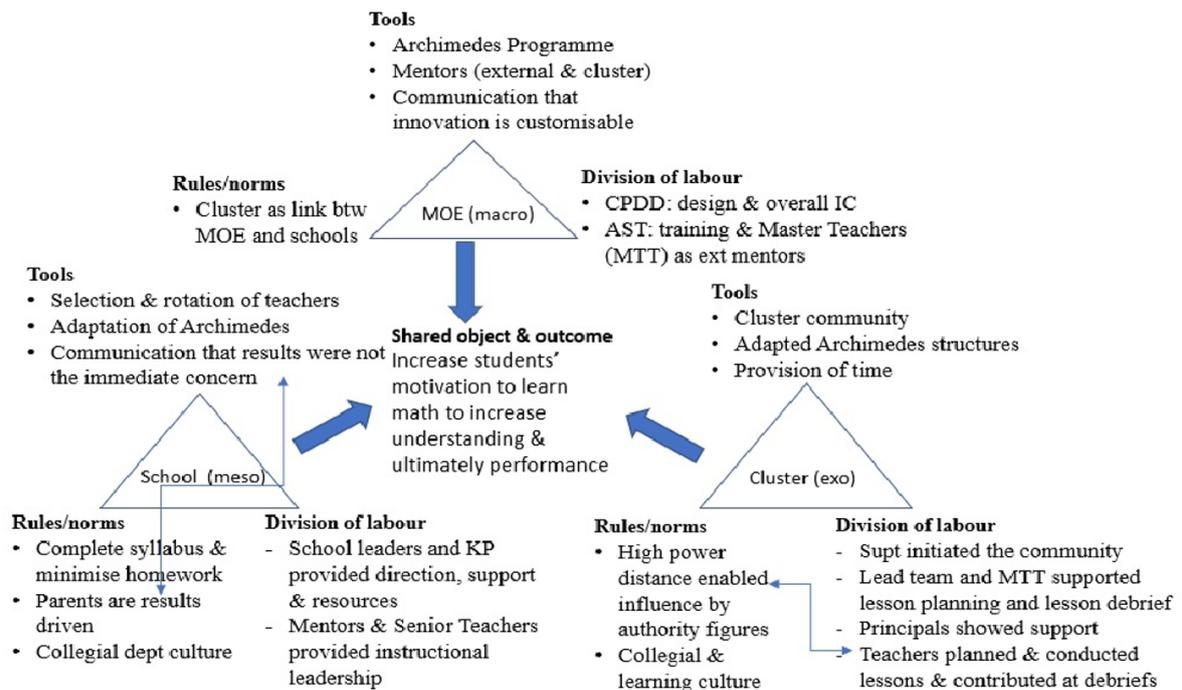


Figure 3: Interactions amongst the three activity systems

In addition, the ministry's communication in its roll out and training of teachers that Archimedes is customisable was taken up by both the cluster and schools in their effort to adapt and integrate Archimedes to meet their schools' unique needs. Another possible influence by the Ministry was its recent focus on the joy of learning to counter Singapore's results-driven culture (Ong, 2019, May 28), which may explain the school leaders' de-emphasis on results.

Although it is not possible to say which was cause and which was effect, the schools and the cluster community both exhibited collegial and learning cultures, suggesting some inter-influence (Uhl-Bien et al., 2007) amongst the open systems of the schools and the cluster.

Finally, MOE's development of distributed expertise in the use of Archimedes enabled various people to provide instructional leadership at different ecological levels. At the school level, mentors for Archimedes were trained and supported by a mentor-mentee structure. At the cluster level, the ministry trained cluster mathematics mentors (CMM) to provide further support. In this study, the CMM was roped in to support the cluster community. The ministry also provided external mathematics mentors (EMM) who usually provide coaching and support at the school level. In this study, the EMM for school C was the Master Teacher, who was asked by the principal of School C to also provide support to the cluster community. The macro-exo-meso partnerships supported the distribution of instructional leadership, building social and collaborative capital across and within schools, enabling interactions and connections between the various ecological levels.

Two main tensions were identified: a) tension between school leaders' communication that results were not their immediate concern and teachers' worry that results were still the main concern for parents and b) tension between teachers' desire to assert their professional expertise and their perception that they should defer to the lead HOD's input. The first tension was resolved by the teachers deciding for themselves the extent to which to

implement the innovation, while the second was 'resolved' by some teachers changing their lessons, despite communication by the lead HOD that her input were just suggestions for the teachers' consideration.

Limitations of the Study

One limitation in representing CHAT in a diagram format is the impression conveyed that activity systems are static in nature, with activities captured at one point in time. In reality, CHAT recognises that transitions and changes are constantly occurring within and between activity systems (Cole and Engeström, 1993). Similarly, the leadership provided in the case study involved actors building on or responding to changing situations or diverse contexts. Figure 4 attempts to illustrate the evolving nature of the leadership provided at various ecological levels, and how this leadership involved interactions across ecological levels. The y-axis represents the ecological levels while the x-axis represents a rough time frame. Mapping leadership activities across times highlights how the Supt built upon the leadership provided by MOE, how schools and teachers actively adapted the innovation, and how the cluster community itself evolved to keep pace with recent MOE initiatives.

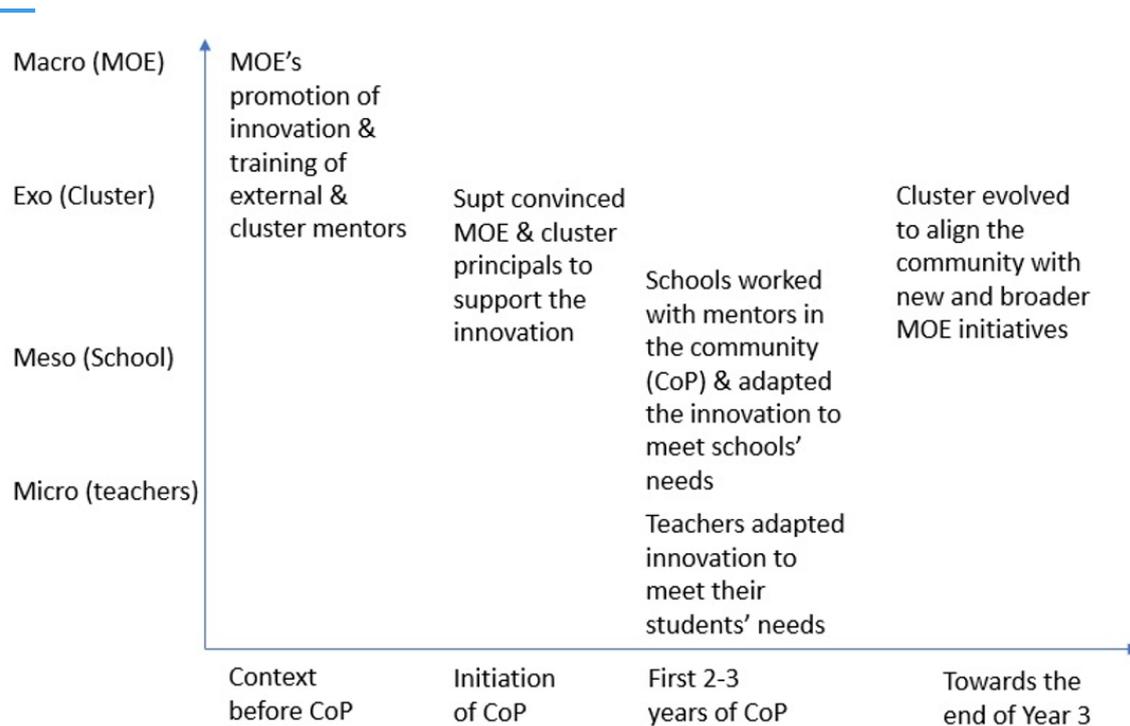


Figure 4: Leadership activities across time and ecological levels

Discussion

From a theoretical perspective, the study and its findings suggest the need to review how distributed leadership may manifest itself within a high-power distance culture (Goh, 2009; Hofstede, 2003). Leaders in such a culture need to be mindful of power distance issues and navigate these to enact and support distributed leadership, as evidenced in this case in which the Supt emphasised the autonomy of school leaders and key personnel to decide whether to adopt the innovation and to provide their own directions. In a hierarchical system, the norm is for people to lead downwards and follow upwards, but both upward and downward percolation is necessary in order to achieve distributed leadership (Hung et al., 2018b), as

seen in the teachers in the study influencing both their peers and their department heads through the former's adaptation of the innovation.

There is also a need to review the concept of 'situation' in the 'situation-leader-follower' triangle that is often used to represent distributed leadership (Spillane et al., 2004). While it might not have been the intention, representing situation within a triangle gives the impression that distributed leadership occurs mainly within a bounded and stable situation with relatively fixed leaders and followers, as demonstrated by distributed leadership studies which focus mainly on one context, usually in a school setting (Ho et al., 2016; Sung et al., 2016; Hirsh and Segolsson, 2019). Integrating distributed leadership with an ecological perspective, and incorporating activity theory, remind us that stakeholders participate in interacting dynamic situations which occur at different ecological levels, particularly in a multi-level hierarchical education system. Followers in one situation (such as principals in relation to the superintendent) are leaders in another situation (principals within their own schools). At the same time, there is room for teachers, who usually play a follower role in a school situation, to enact leadership in a different ecological setting, such as in the cluster community, if power in that situation is based on expertise or experience rather than just position.

For the sake of simplification, discussion was limited to three main activity systems. In reality, each can be broken down into more activity systems for a more nuanced understanding of leadership practice within a specific context. For example, at the school level, there are at least two activity systems: senior management and the subject departments. As each activity system has its own rules, norms, and likely several desired objects/outcomes, how the activity systems interact, productively or otherwise, would depend on whether the activity systems share outcomes, and whether the division of labour makes sense to their communities.

At the school meso level, this article presented the findings aggregated across six schools. In reality, each school is a different activity system, with a different community, and differences in object, tools and division of labour. In addition, for individual teachers at the micro level, their class profiles, their personal teaching experiences, and even their personalities shaped the leadership they provided and their implementation of Archimedes. At the teacher level, certain tools and norms also impacted them more directly, such as the lesson plan template and the time provided to participate in the cluster community. Each teacher's individual activity system may also interact in distinctive ways with the school's activity system.

Although the third generation of Activity Theory enabled us to analyse the case across macro, exo and meso levels, the chrono layer is difficult to represent as an activity system by itself. Nevertheless, the influence of the chrono layer is usually seen in the cultural or social norms of the different activity systems. CHAT's argument is that culture is history in the present (Cole and Engeström, 1993). Activity Theory views activity systems as inherently dynamic systems which evolve and develop over time. Adopting CHAT as a lens to analyse leadership reminds us that there is a temporal dimension to leadership and that leadership activities evolve over time as leaders adopt or modify actions in response to followers' actions or to the broader educational landscape.

Analysing leadership across activity systems and at different ecological levels accentuated leadership at lower hierarchical levels. Teachers clearly showed they had autonomy to customise their lessons to meet their students' needs. Indeed, one concern researchers had was whether teachers had modified Archimedes to the extent that it could no longer be referred to as an Archimedes lesson. However, this did not appear to worry the ministry or the school leaders and heads of department, who supported their teachers' agency in making personal sense of Archimedes.

Conclusion

The integrative perspective surfaced leadership practices by different stakeholders at various ecological levels, from the meso level of schools to the exo level of a cluster of schools to the macro level of the Ministry of Education. The use of the third generation of CHAT as a theoretical lens assisted in understanding how the different activity systems at the ministry, cluster, and school levels worked together in providing leadership for the implementation of an innovation, the tools utilised, the rules/norms which enabled or constrained the innovation's implementation, and the evolving nature of the leadership provided.

The study affirms the utility of the cluster structure in a centralised education system in providing a link with the ministry and its resources while simultaneously serving as a platform for collaborative professional development and the diffusion of innovations. In leading from the middle, the cluster structure as a system strategy (Fullan, 2015) enables boundary spanning between the ministry and schools, and thus arguably a more efficient way for the ministry to reach out to schools to promote centralised reforms.

At the same time, the study suggests that despite the generally high power distance culture in Singapore (Goh, 2009), when teachers feel they are empowered, and supported by a collegial environment, they exert both agency and leadership, customising and adapting innovations introduced from the top. The case also illustrates how it is possible in a high-power distance context to achieve some balance between centralised control and decentralised autonomy at the school and teacher levels to enable the customisation of policies and innovations to meet unique schools' and students' needs. This is consistent with findings in another highly centralised system, in Vietnam, in which a combination of external and internal enablers supports the implementation of educational reforms (Dimmock et al.,

2021). Even in countries with different cultural contexts, educational systems would still be 'nested' within an ecological system with the potential for leadership to be enacted at different levels.

Future studies of how multiple levels of leaders work together to implement system reforms might wish to include quantitative methods, such as the use of surveys and structural equation modelling or social network analysis, to explore further the complex interactions and roles played by different leaders, and how these influence the reform outcomes. It would also be worth exploring in more detail the tensions which arise from balancing centralisation with decentralised customisation and innovation, and how these can be resolved.

Underlying research materials can be accessed at <https://researchdata.nie.edu.sg/>

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