
# Are Future Generations Future-Ready?

## Investigating Associations between Higher Order Skills Learning and Participation in Sustainable Development Issues

### The Case of High School Students in Chennai, India

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This document represents part of the author's study programme while at the International Institute of Social Studies. The views stated therein are those of the author and not necessarily those of the Institute.

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# List of Acronyms

| | |
|---|---|
| UNESCO | The United Nations Educational, Scientific and Cultural Organization |
| OECD | Organization for Economic Cooperation and Development |
| CBSE | Central Board of Secondary Education |
| IGCSE | International General Certificate of Secondary Education |
| ESD | Education for Sustainable Development |
| ISS | Institute of Social Studies |
| NEP | National Education Policy |
| ILO | International Labour Organization |
| IHD | Institute for Human Development |
| MCA | Multiple Correspondence Analysis |
| UNICEF | United Nations International Children's Emergency Fund |

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## Abstract

As the world continues to face problems such as climate change and advances in AI, there is a need for our present education systems and those of our future to keep pace. India has attempted a move in this direction with the National Education Policy 2020, emphasising the development of students' higher order cognitive skills such as critical thinking in encouraging positive contributions to sustainable development. However, there appears to be a lack of literature on the policy's influence i.e., measuring higher-order skills metrics and its relationship to sustainable development participation. Hence, this study aims to use 'Education for Sustainable Development (ESD)', a UNESCO framework emphasising specific higher-order cognitive skills towards sustainable development participation, to quantitatively analyse higher order skills metrics. But literature on the framework appears scanty on standardized metrics. To address this gap, the study aimed to pilot and measure ESD skills learning metrics through students' perceptions towards their pedagogy and facilities in school. Metrics were further analysed against students perceived future participation in sustainable development issues. Primary surveys were distributed online to high school students from 10th-12th standards belonging to a private State Board school in Chennai, India. Analysis was conducted using Multiple Correspondence Analysis (MCA) and k-means clustering methods to measure whether associations exist between students' ESD skills learning in school and their perceived future participation in sustainable development issues. Results show clear associations between students' perceptions on ESD skills learning in school and perceived participation in development issues. These findings provide key implications to policymakers and educationalists on the significance of practical skill development within Indian schools.

## Relevance to Development Studies

As we traverse the 21st century, the world's economies are beginning to understand the significance of practical skills learning in securing impactful jobs and as a result actively tackling various sustainable development issues such as climate change and social inequality. For a country like India lauding the biggest education system in the world, ascertaining the extent of practical skill development within its schooling institutions becomes pertinent. This study aims to highlight ways to measure higher-order skills development in Indian schools, along with its associated influence on students' participation in sustainable development issues.

### Keywords

higher order thinking skills, Education for Sustainable Development (ESD), education policy, student motivations, pedagogy, learning environment

# Chapter 1
# Introduction

Education systems around the world have commonly measured learning outcomes of its students via lower-order cognitive skills such as literacy and numeracy. However, the measurement environment around learning objectives has gradually begun to evolve to also include critical higher order thinking skills such as systems thinking and collaborative learning (OECD, 2023).

In a country like India lauding one of the biggest education systems in the world with over 1.5 million schools and nearly half of all its students attending private schools (Central Square Foundation, 2020; UNICEF India, 2018), it is imperative to understand whether the country's private schools are keeping up with the times. The recent policy National Education Policy (NEP), 2020 has been touted as a positive move towards creative education progress in the country, with a vision to promote learners' responsible citizenship and active contributions towards society (Government of India, 2020). The underlying question becomes: Have the country's schools been able to deliver on the policy's objectives? To uncover the answer, it is pertinent to first examine the progression of the country's education landscape thus far.

## 1.1 Overview of India's Education Context

During the 19th and 20th centuries, lack of school enrolment and access acted as detriments to progress in the Indian education system. Hence, past education policies in the country attempted to rectify this issue (Government of India, 2020). Since then, considerable progress has been made with gross enrolment rates of primary school children reaching 108% in 2022 compared to 77% in 1971 (World Bank, 2023). Key cognitive measures such as literacy rates have also improved, recording a 30% average increase between 1970-2022 (Statista, 2023). But these increases are found to be driven by individual Indian states' performances. One such Indian state positing these improvements has been the Indian state of Tamil Nadu, reporting a literacy rate of 80.1% as per the latest census (Government of India, 2011).

While quantity of education measures such as enrolment and literacy rates have been improving in the country with some states driving the change, calls to question on the quality of education have been made. Rigid curricula have been cited as one such factor – for instance, environmental education has been mandated in schools but focuses only on environmental indicators like environmental regulation and wildlife conservation, neglecting its interrelationships with social aspects such as human health (Iyengar and Bajaj, 2011). Additionally, the country's education systems have widely been argued to focus more on rote learning, limiting the creative potential of students (Mehra A., 2021).

The extent of its presence in school settings, however, is found to differ across India's school types – government and private. Government schools tend to focus more on education accessibility via fee subsidies, while promoting baseline education outcomes through its primitive infrastructure, curricula and teaching methods. In contrast, private schools typically demand higher school fees and boast of advanced infrastructure and learning resources to enhance students' learning beyond basic cognitive skills (India Development Review, 2023).

Scholars have cited evidence of better-quality learning outcomes from the latter due to active teacher presence and pedagogical practices including using textbooks and checking students classwork (Singh, 2013; Muralidharan and Kremer, 2007).

But differences are more nuanced as they are also found across education boards. Schools operating under the national education board, Central Board for Secondary Education (CBSE), lean more towards higher-order skills development with exams testing students on their "ability to reason, justify, analyse and evaluate information" (Sahay, 2019), with other international boards in the country such as Cambridge IGCSE also following in toe (Podar Education Network, 2023). Conversely, state-managed education boards or State Boards, arguably possess rote learning tendencies with a focus on merely recalling facts without a complete understanding of concepts (21K School, 2024). Regardless of board however, pressures on students to get the highest scores in examinations, rather than focus on the skills gained from it have been a universal issue across the country's education systems (Mehra, A., 2021).

As the 21st century progresses, it is being confronted with a set of interconnected problems such as climate change, inequality and technological advances such as machine learning and AI, making it crucial for the presence of a skilled labour force who possesses multidisciplinary knowledge and can think outside the box to positively further societal progress within the changing development landscape (Government of India, 2020). To meet these demands, the Government of India has since introduced the "National Education Policy 2020" or NEP - a novel education policy which desires to reform the current education system - moving away from a rote learning approach towards the *"development of the creative potential of each individual"*, which includes a multidisciplinary curriculum and developing practical skills such as higher-order cognitive skills among others e.g., non-cognitive skills, digital skills, etc. (ibid). The aim of the policy is *"…to develop knowledge, skills, values, and dispositions that support responsible commitment to human rights, sustainable development and living, and global well-being…"* (ibid.) – showing a clear commitment of the government towards developing responsible citizenship traits amongst students regarding sustainable development issues.

## 1.2 Research Gap(s)

However, since the release of the NEP policy, there appears to be a lack of literature on measurement of one of the policy's inputs i.e., higher-order cognitive skills learning in Indian schools, the output i.e., students' perceived participation in sustainable development issues in the future, and the associations between them.

To address the input research gap, UNESCO's education framework 'Education for Sustainable Development (ESD)' was identified for the study's purpose. The framework emphasises a set of higher-order thinking skills needed for learners to actively contribute towards sustainable development issues (UNESCO, 2012). However, this framework appears to lack standardized quantitative metrics, with metrics primarily being qualitatively measured through interviews and case studies.

From the output research gap perspective, there appear no established studies on Indian school students' perceptions of their participation in sustainable development issues in the future. In particular - their perceived engagement levels taken in a future workplace on these issues and their perceived self-efficacy levels to tackle them.

## 1.3 Objectives of the Thesis

Considering the measurement gaps towards the NEP policy's deliverance on higher order skills, the research aims to use a precursor framework 'Education for Sustainable Development (ESD)' as a proxy to establish measurable skills for these schools. As there exists no standardized assessment to quantitatively measure ESD higher-order skills, this study aims to pilot survey questions using existing ESD literature towards high school students belonging to an Indian school in the state of Tamil Nadu. Moreover, as there lacks literature on the measurement of the policy's output of participation in sustainable development issues, the study also aims to formulate survey questions based on existing global literature on students' civic attitudes, engagement and self-efficacy.

Resulting from these aims, the study would like to proceed with the following objectives:

1. Establish ESD skills learning metrics based on existing literature to provide an empirical framework for higher order skills assessments in schools

2. Analyse its associations with students perceived future participation in sustainable development issues through two factors:

- perceived future engagement level on sustainable development issues in their future workplace
- perceived self-efficacy in their skill level to tackle sustainable development issues in their future

As mentioned in Section 1.1, the state of Tamil Nadu appears to perform well on lower-order cognitive skills such as literacy, but this study attempts to dive deeper into its schools' delivery of higher-order skills learning and its relation to students' participation in sustainable development issues. The choice of school for the study was a State Board private high school located in the metropolitan city of Chennai in Tamil Nadu. It was chosen as it possessed an education board i.e., State Board, traditionally known for its rote learning characteristics, at the same time being private in its setup implying a greater quality of infrastructure, curriculum and teaching pedagogies vis-à-vis government schools.

The survey is used to measure students' perceptions specifically on teachers' pedagogy[1] and school facilities[2] in providing ESD higher order skills learning. Additional questions on perceived future participation in sustainable development issues through perceived attitudes, engagement and self-efficacy are also collected. With this information, the thesis aims to understand whether associations exist between ESD skills provided in the chosen school and its students perceived future participation in sustainable development issues. Furthermore, this study aims to draw only correlational trends and not causational impact from the results.

By identifying potential relationships between students' perceptions on higher order skills learning in school and their perceived future participation in sustainable development issues, findings from this research could inform State Board school administrations on whether improvements in their pedagogy and facilities are necessary to encourage higher engagement levels and self-efficacy of their students towards sustainable development issues.

[1] As defined by the University of Minnesota, *"Pedagogy is the combination of teaching methods (what instructors do), learning activities (what instructors ask their students to do), and learning assessments (the assignments, projects, or tasks that measure student learning)".*

[2] School facilities in this study include activities outside the classroom setting such as clubs and workshops

As the study also attempts to monitor progress on the NEP policy using the ESD framework, findings from this research could also provide insights on a broader scale towards educational policymakers in the design of standardized higher order skills indicators and outcome metrics for schools, both at the state and national level.

The paper will consist of the following sections. Section 2 focuses on the literature review highlighting the ESD framework and factors closely associated with it. Section 3 describes the data and empirical design. Section 4 and 5 comprises the results and discussion respectively. Section 6 concludes.

# Chapter 2
# Literature Review

## 2.1 Conceptual Framework – Education for Sustainable Development (ESD)

The term "sustainable development" has received widespread recognition in the global policy sphere, mainly popularised by the United Nations Brundtland Commission 1987 (European Union, no date):

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

This definition while appearing vague captures two facets integrated with economic development – the needs of social wellbeing and the environment (Adams, 2006)- taking inspiration from academic literature by scholars at the time who argued the interlinkages between pillars of society, economy and environment in the process of development (Purvis et al., 2019). Arising from these definitions, the UN had proposed indicators to measure progress on these pillars vis-à-vis the SDGs (Sustainable Development Goals) to be reached by 2030 (Bonn Alliance, 2021). The goal primarily accounting for the dimension of education is Goal 4: quality education for all. While targets within this goal typically cover indicators related to education access, teacher supply and inclusive facilities, Target 4.7 addresses in particular the purpose of education and its role in promoting active engagement with sustainable development issues (UNESCO, 2020).

To measure progress on this target, the global theoretical framework "Education for Sustainable Development (ESD)" had been developed by UNESCO. Building on previous implementations of ESD since 2005, the most recent "ESD for 2030" introduced in 2020 possesses the vision to:

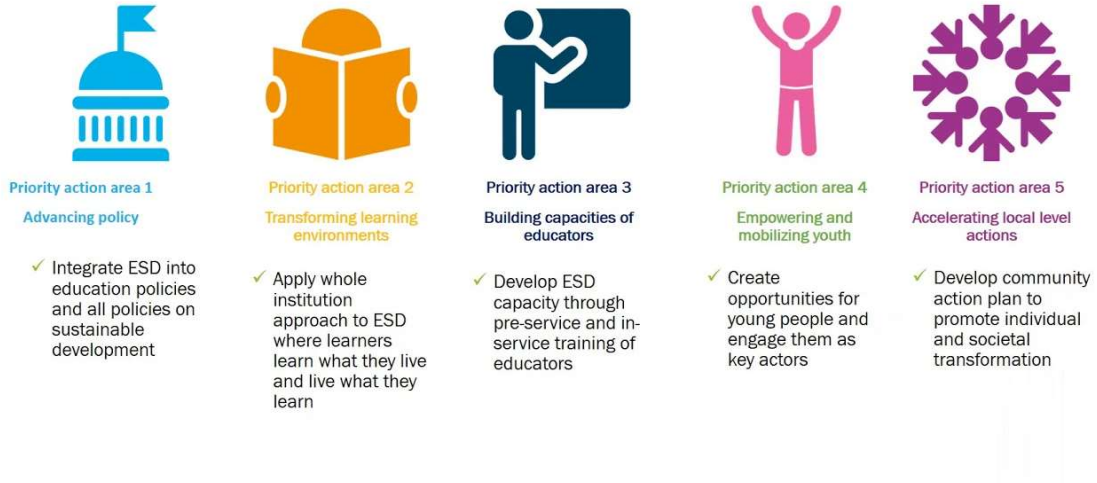
"give[ ] learners of all ages the knowledge, skills, values and agency to address interconnected global challenges including climate change, loss of biodiversity, unsustainable use of resources, and inequality" (UNESCO, 2024)

To implement this vision, the framework emphasizes two key criteria to ensure positive learning outcomes and societal transformation for active learners of sustainable development:

1. *Learning content:* Imparting sustainability knowledge towards learners via holistic curricula. The curricula would provide students with technical knowledge on specific sustainability topics (eg., climate change education). Within specific sustainability topics, the role of ESD would be to integrate dimensions of environmental, social and economic nature within subjects' curricula (Hedefalk et al., 2015).

2. *Pedagogy and learning environment:* Students learning environments would be transformed via pedagogical practices such as learner centred, collaborative and practical based learning. Internationally implemented pedagogies include project-based learning, curriculum-based storytelling, participatory research – with the aim of improving cognitive and socio-emotional skills (Teixeira and Crawford, 2022; Monroe et al., 2019)

Fig. 1: Priority Areas of UNESCO's ESD framework




Source: UNESCO (2023). Available at: UNESCO_B.Combes_ESD_for_2030_FINAL.pdf (unece.org)

While ESD is a comprehensive framework which is meant to be implemented across different stakeholders such as governments, education institutions, teachers and youth (Fig.1), this study chooses to focus on the institutions' perspective i.e., **priority area 2: 'transforming learning environments'** as it specifically considers (re)designing institutions via their content and pedagogies to encourage students in becoming 'change agents' in action towards sustainable development. As a result, the study would explore the learning environment via pedagogy and facilities of a selected Indian high school and its link to students' higher-order skills. Illustrated in the following subsections, the study utilises a foundational classification of (higher-order) cognitive skills developed by educational psychologist Benjamin Bloom, and further builds on this with higher-order skills definitions provided by UNESCO as part of the ESD framework.

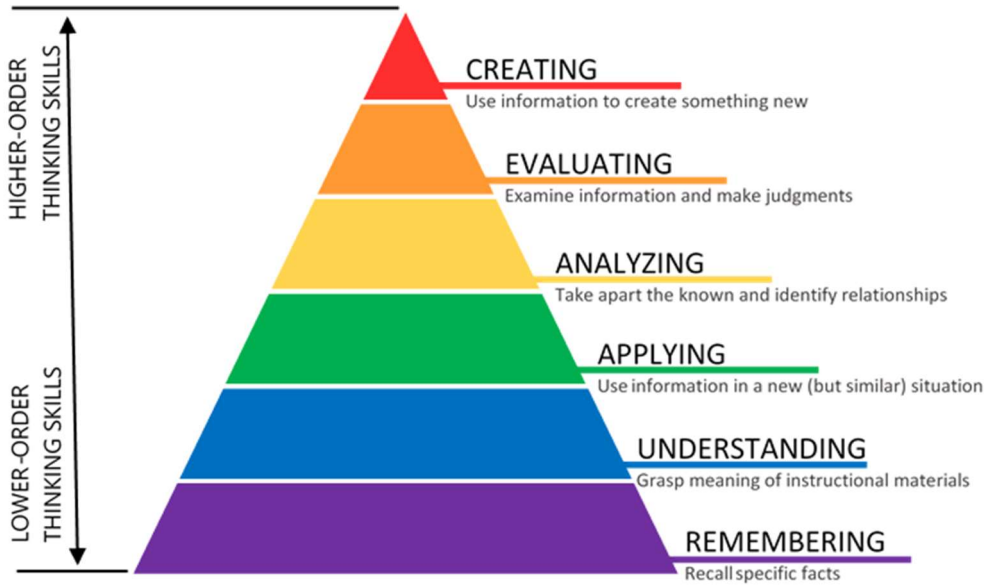
### 2.1.1 Bloom's Taxonomy of (Higher-Order) Cognitive Skills

Cognitive skills refer to the functions involved in helping the brain remember, reflect and act on information received. The earliest literature defining the type of cognitive skills and its level of importance was first introduced by Bloom (1956). As per Bloom's taxonomy (Fig.2) adapted later by Anderson et al. (2001), such skills are hierarchically placed on a pyramid beginning with low-order cognitive skills to be attained first such as 'remembering' through memorization and 'understanding' and 'applying' through literacy and numeracy. High-order cognitive skills located higher up in the pyramid include 'analyzing', 'evaluating' and 'creating' via actions like critical thinking and problem solving (Pegg, 2010).

In the context of education, much attention has been paid to the role schools have provided in improving general cognitive abilities and academic performance as a result (Peng and

Kievit, 2020). The benefits of enhancing these skills have also been attributed to better future earnings and economic growth (Hanushek and Woessmann, 2008). While lower-order skills like working memory have been emphasised through rote learning (Yadav, 2022), literature has also pointed towards the role of creative learning with higher-order thinking competences in schools (Miri et.al, 2007; Miterianifa et al., 2021). Conklin (2011) has argued the necessity for higher-order thinking skills is to ensure students' academic success but also their positive future contributions to society.

Fig.2: Bloom's Taxonomy – Cognitive Skills Hierarchical Pyramid




Source: University of Florida (n.d) Available at: Bloom's Taxonomy Graphic Description - Center for Instructional Technology and Training - University of Florida (ufl.edu))

### 2.1.2 UNESCO's Framework of Higher-Order Cognitive Skills

According to UNESCO (2018), the ESD higher order skills students should acquire to actively tackle sustainable development issues include:

1. *Envisioning:* Forecasting future sustainability scenarios based on past and present information on related topics
2. *Critical Thinking and Reflection*: Analysing opinions/judgements related to the environmental, social and economic structures of sustainable development and reflecting on them
3. *Systems Thinking:* Examining linkages and relationships within complex sustainable development problems such as climate change and inequality
4. *Building Partnerships:* Learning to work together and cooperate with people to solve practical sustainable development problems
5. *Empowerment:* Encouraging participation in decision-making processes within and outside educational settings

While scholars have since attempted to divide these ESD skills based on different domains (Taimur and Sattar, 2020), there appears to be sparse literature on the criteria needed to teach each of these skills effectively. A singular exception appears in Frijters (2016) who defined these skills further, attempting to account for overlaps in meaning and provide specific criteria under each skill (*Annex A – Table S1*). These criteria were qualitatively measured with teachers in a Dutch school, where teachers were required to practically execute these criteria in their teaching environments. The study showed positive results where teachers, after asking clarifying/reflective questions, stimulated students to think critically about their own ideas on sustainability issues. While this study produces a clearer delineation of these skills, its implementation occurs purely in a Dutch context. In the Netherlands, students can choose among different school tracks for secondary school i.e., pre-vocational secondary education (VMBO), general secondary education (HAVO) and pre-university secondary education (VWO), coming with its own set of objectives and curricula (Government of Netherlands, n.d.). These factors potentially reduce the replicability of this methodology within educational systems in other contexts which have a more linear and inflexible progression in educational levels.

In order to develop ESD skills, teaching pedagogies recommended include but are not limited to simulations of real-life sustainability scenarios, active classroom discussions and research analysis on sustainability issues (UNESCO, 2012). These techniques are proposed to aid in the development of key skills such as critical thinking and collaboration through active participation in school activities related to sustainable development (ibid.). One of many real-world examples include schools in Finland which adopted a 'phenomenon-based' learning approach, emphasising interdisciplinary and practical understanding of issues such as climate change, food production and water quality (Lähdemäki, 2019). Students were able to acquire knowledge and skills on these topics through stakeholder interviews, field observation and data collection and analysis.

## 2.2 Students' Participation in Sustainable Development

A challenge highlighted, however, in measuring ESD knowledge and skills is to analyse whether this learning has further translated into positive sustainability attitudes and actions (UNESCO, 2017). But the ESD framework has largely been argued to correlate with civic engagement indicators as per literature by Schulz et al. (2023). For instance, civic engagement domain classifications such as 'Cognitive domain 2: Reasoning and applying' draws parallels with ESD cognitive skills such as critical thinking and envisioning (Schulz et al., 2016). Students' participation in school activities are considered an influential factor in improving prospects of their citizenship engagement in the future (Pancer, 2015).

According to Schulz et al. (2016), beliefs, perceptions, dispositions, and behaviours among students towards civic engagement in development issues can be related to three factors: perceived attitudes, engagement and self-efficacy.

### 2.2.1 Perceived Attitudes

Literature has referred to youth attitudes towards participation in development issues as their analysis and judgment of ideas and situations which could appear contradictory, be subject to change or remain stable over time (UNICEF, 2020; Ajzen, 2005). Despite challenges in measuring ESD and relating attitudes, studies have showed promising results in this regard.

Kopnina (2013) used an Ecocentric and Anthropocentric Attitudes toward the Environment (EAATE)[3] scale to measure whether university students studying an ESD curriculum showed more pro-ecological or pro-anthropogenic motivations regarding environmental issues. In addition to direct attitude measurement, scholars have also analysed the perceptions of secondary students towards development issues in their future at a personal, national and/or global scale (Zerihun and Dawit, 2024; Anguera and Santisteban, 2016; Schulz et. al, 2016).

### 2.2.2 Perceived Engagement

Another mode of analysing participation has been through measures of civic engagement found to be correlated with criteria of the ESD framework (Schulz et.al, 2023; UNESCO, 2017). Here, Schulz et.al (2016) mean civic engagement to be "the expected future actions and willingness to get involved in society when adolescents become adults" (Alva et. al, 2023). Tedeschi et al. (2021) reviewed civic readiness survey scales which measure students' civic attitudes, knowledge and their perceived future engagement with issues related to the environment (eg., recycling behaviour), community (eg., helping needy people) and politics (eg., voting).

But to explicitly test students' perceived behaviour when exposed to an environment with a development issue, Holdsworth et. al (2018) framed case-vignette scenarios towards university students. The scenarios focused on assessing levels of engagement - awareness, responsibility and leadership - which graduate students perceive they would undertake towards a newly identified environmental impact in their workplace, given their workplace has no concern for it (*Annex B - Table S2*).

### 2.2.3 Perceived Self-efficacy

Apart from perceived actions undertaken by students, literature has also pointed towards the role of self-efficacy in shaping their perceptions of participation in development issues. In accordance with literature by Bandura (1997) and his work on Social Cognitive Theory, self-efficacy refers to:

"an individual's belief in his or her capacity to execute behaviours necessary to produce specific performance attainments"

The earliest literature on the role of students perceived self-efficacy in academic settings comes from works of Collins (1984) later followed up by Ayotola and Adedeji (2009). These scholars found that students with a strong level of mathematical ability and having strong beliefs in their ability were more likely to rework problems in which they had initially failed, compared to students with the same ability exhibiting self-doubt. Additionally, Lin (2021) shows self-efficacy in science learning amongst high school students - such as believing in their own ability to critically evaluate solutions to scientific issues – contributes to their greater engagement in science learning.

According to Bandura (1993), self-efficacy in one's own skills also proves crucial in setting higher personal goals and committing to them. An example cited from this finding is the career path and development of students (Betz and Hackett, 1986). It is argued that a stronger belief in their own self-efficacy leads to multiple positive outcomes such as greater perception of career options and an interest in pursuing them, better educational preparation for these

[3] Questions included "Humans are justified drilling for oil as it satisfies economic needs, even though it might be bad for the environment", "The most important reason to keep lakes and rivers clean is so that people have drinking water"

options, and stronger stability and success in these options (Bandura, 1993). In this regard, Putri et.al (2021) piloted a scale to high school students in Indonesia to measure their self-efficacy on career planning and readiness. Furthermore, Nisa et. al (2021) found strong linkages between Indonesian students' higher-order thinking skills like problem solving and critical thinking, and their own self-efficacy on higher work preparedness.

## 2.3 Other Factors Affecting Students' Participation

### 2.3.1 Personality Traits

Students' attitudes towards engagement in sustainable development issues could also be influenced by factors outside their education system such as their own personality traits. Recent literature has shown that an increase in Sustainable Attitude Behaviours (SABs)[4] have been associated to changes in traits such as Openness, Agreeableness and Humility (Hopwood et al., 2022). Soutter and Mõttus (2021) analysed these traits in more detail, with findings to suggest that sub-domains of Agreeableness such as Sympathy and Altruism were the driving forces of pro-environmental behaviours and attitudes in undergraduate students. Arguably, personality traits were also found to influence attitudes towards social and economic issues (Gallego and Pardos-Prado, 2014; Gerber et al., 2010). Past studies have also used the Big Five Personality questionnaire to measure personality characteristics specifically in the context of high school children (Cupani et al., 2020). However, scholars have argued the limitation of this approach is its non-applicability to non-WEIRD contexts such as India, as the standardized scaling of these traits has predominantly followed a developed country centred focus (Laajaj et al., 2019). Despite this limitation, scholars in India have attempted to modify existing scales of personality traits in school settings (Bairagya and Mukerji, 2019).

### 2.3.2 Parental Influence

Literature finds strong evidence of social influences on students' decision-making towards their higher education and career choices (Hlad'o, 2013). In particular, parents are seen to be one of the most influential factors (White, 2007). In relation to children's participation, studies have also shown that parents involvement in social, civic and political issues greatly influences their children's engagement in the same (Schulz et al., 2010; Zukin et al., 2006). Cicognani et al. (2012) analysed gender differences within this relationship, showing that female students were more positively influenced by their parent's engagement with social and political issues than male students.

### 2.3.3 External Learning Platforms

Apart from school material and pedagogies, students' engagement in development issues could also be influenced by external learning material. Studies have shown the benefits of reading physical resources like non-fiction books on developing higher-level thinking skills such as conceptual analyses of topics, investigative attitudes towards their own ideas, knowledge sharing with peers and self-efficacy (Job and Coleman, 2016). But in recent times, an additional avenue of education has been developing - digitalisation of learning content (Statista, 2020). Studies have shown the impact of e-learning among university students to be multifold including communication and critical thinking skills (Khan and Setiawan, 2019). Notably, recent studies have also cited contradictory views, with students reporting e-learning tools as ineffective in promoting these skills (Alenezi et. al, 2024).

[4] Sustainable attitudes (e.g., beliefs, concerns, values) and behaviours (e.g., purchasing, voting, recycling) relevant to promoting a more sustainable environment (Geiger et al., 2018).

Positive attitudes towards news and current events have also been linked as predictors of youth's active civic engagement in world development issues (Hobbs et al., 2013). But the mode of news consumption especially from digital platforms is found to impact their civic engagement differently. Hao et. al (2014) found significant effects on university students' engagement with news consumption through the internet and social media sites as opposed to traditional media platforms. In addition, the role of AI tools like ChatGPT has been proposed as transformative in shaping ESD skills, with ethical debates around its usage still underway (Abulibdeh et. al, 2024).

## 2.4 Global State of ESD Implementation and Measurement

While the broader implementation of ESD has been widely observed particularly in the case of universities through curriculum creation and national strategy plans (LERU, 2024), some evidence of ESD skills benefits have specifically been witnessed in the school setting. Laurie et al. (2016) used qualitative interview reports to analyse the role of ESD in primary and secondary schools across 18 countries ranging from Peru to South Korea. The authors found schools which implemented ESD curricula reported high student performance, albeit with no confirmation on its causal effect. But they also reported significant effects of schools' ESD pedagogies on increased students' confidence and abilities such as critical thinking and better research skills to partake in real-world sustainability issues in the future (ibid.). Similar results were also found in other studies conducted at the school level (Icihnose, 2019).

Although ESD implementation and its benefits appear promising, the framework does not come without certain limitations. According to UNESCO (2018), there exist knowledge gaps in the measurement of ESD learning outcomes and quality of implementation. Calls have been made for more monitoring to be conducted, from large-scale assessments like PISA which focus on measuring competences in OECD countries related to science literacy and integration of environmental science topics in school curricula (OECD, 2017; UNESCO, 2018). However, this form of measurement had later been argued to be insufficient in shaping transformative action of learners (UNESCO, 2020). As a result, the PISA assessment has since been modified to also measure the extent of creative thinking in schools, which has cited barriers such as congested curriculum, and lack of teacher training and assessments towards creative thinking (OECD, 2023). Apart from national level monitoring, contextualised school/local institution assessments have also been recommended to monitor progress of ESD delivery and improve it further (UNESCO, 2018).

Barrett (2016) argues that current global testing of education measures is more "results-based", with emphasis on learning outcomes such as numeracy and literacy scores. Despite ESD scholars calls for more focus on metrics to measure skills like learner collaboration and participation on sustainable development activities, the framework itself is claimed not to be widely understood, leading to a lack of standardized measures (ibid.). Stemming from this problem, existing studies on ESD implementation provide more qualitative insights (Laurie et al., 2016), as opposed to quantitative with few exceptions in the context of universities curricula (Biasutti and Surian, 2012; Valderrama-Hernández et al., 2020).

### 2.4.1 State of ESD and Sustainable Development Participation in India

In India's context, academics have highlighted the importance of ESD for the country's education systems, making connections to visions illustrated in the central government's NEP policy (Mundhe, 2023; Bangay, 2016). Under the policy's purview, learners should hone skills in their learning environments including cognitive skills such as numeracy, literacy, but also higher-order cognitive skills (eg., problem solving, critical thinking) and non-cognitive socio-emotional skills.

However, the implementation of ESD in India appears stalled with reasons cited such as lack of awareness and understanding of ESD, poor cooperation of governments and other institutions, prevalence of outdated pedagogical techniques like rote learning, lack of financial resources towards teacher education and curriculum development (Choudhary, 2022). Researchers have also pointed to potential gaps between the NEP policy's design and implementation (Muralidharan and Singh, 2021).

Under the country's government structure, implementation of education policies is typically exercised by states (Government of India, 2024), potentially resulting in a staggered implementation across the country. For instance, the Government of Tamil Nadu opposed the NEP implementation and began drafting its own State Education Policy in 2022 (The Hindu, 2023). While it has not been released yet, it has still cited emphasis on quality education with respect to "learning outcomes" and "employment-ready skills" (ibid.). However, since the central/state governments announcement of their policies, there appears to be a lack of literature on whether Indian schools have been able to deliver on ESD skills effectively through their teachers' pedagogy and school facilities.

In relation to students' perceptions of sustainable development issues, Indian school students have largely reported major concern for environmental issues such as climate change across different states in the country (Goel et al., 2023; Harju-Autti, 2013). However, little to no literature exists for the country on students' perceived future participation in these issues, i.e., their future perceptions of sustainable development issues from the lens of the three pillars (society, economy and environment), their perceived engagement towards such issues in a future setting, and perceived self-efficacy on their present skills to tackle these issues in the future. Moreover, other factors identified in the literature potentially affecting student participation such as personality traits, parental influence and external learning platforms have also not been explored in this context.

# Chapter 3
# Data and Empirical Design

## 3.1. Survey Data

The study draws on a cross-sectional survey towards $10^{th}$-$12^{th}$ standard high school students from a private State Board high school in Chennai, Tamil Nadu, India. The survey and consent form dissemination were coordinated through online and telephonic discussions with the school administration. Consent forms and surveys were distributed online via Google Forms through student WhatsApp groups administrated by the teachers. Students were requested to show parental consent forms to parents for approval prior to filling in the survey. This dissemination process was cleared by the school, with assurance that parents would be fully informed on their child's participation.

Once consent was obtained, students were immediately linked to the survey. Students were provided with information on the survey, their role and a request for voluntary consent. Out of approx. 480 students belonging to the high school, 74 students/parents indicated their consent, with 60 valid responses containing both parental and student consent. Data collection took place between July-August 2024. Potential limitations arising out of the data collection process was a smaller sample size and students' self-selection into the survey.

Before administering the survey, a pilot survey testing was conducted with two cohorts: Indian students at ISS (n=10) and the target population (n=10) i.e., Indian students in private Chennai high schools albeit belonging to different boards apart from State Board such as CBSE, IGCSE, etc. Feedback from these pilots was then incorporated into the final survey. The survey took on average 10 minutes for students to complete.

The following subsections illustrate the survey questions used to measure the study's variables of interest i.e., students' perceptions of ESD skills learning in school and their perceived future participation in sustainable development through three factors – attitudes, engagement, self-efficacy. Apart from the mentioned factors, the survey also includes student characteristics such as gender, class standard, study specialization and years studied in the school.

### 3.1.1 ESD Skills

The ESD skills provided towards students by their school is measured using Frijters (2016) ESD design principles. Despite a potentially low external validity due to its Dutch specific context as mentioned previously (i.e., optional secondary school tracks), questions are still drawn from the study as it proposes a clear delineation of skills compared to sparse literature on the topic. Select design criteria within those principles were chosen from each ESD principle and repurposed into survey questions considering the school context of the students. Students were asked to think about their school setting on theory subjects taught within their streams (social/natural sciences) when answering the following questions (Table 1). The questions were measuring using a Likert Scale, with a range 1-Strongly Disagree to 5-Strongly Agree.

Table 1: ESD Skills Survey Questions Based on Frijters (2016)

| **Design Principle** | **Design Criteria** | **Repurposed Survey Question** |
|---|---|---|
| Student Oriented | Always account for your prior knowledge on concepts | Q1 During your classroom lectures, teachers always: Account for your prior knowledge on concepts |
| | Teach with examples that are recognisable and meaningful to you | Q2 During your classroom lectures, teachers always: Teach with examples that are recognisable and meaningful to you |
| Systems Thinking | Work on gaining insight into the relationships that characterise environmental problems. | Q1 During your classroom lectures, teachers always: Teach about a particular topic from different perspectives (i.e., apart from the main subject's perspective) |
| | Let students work on a concrete scenario with multiple causes and consequences, but also with multiple potential solutions. | Q2 For your group/individual assignments, teachers always: Let you analyse a problem with multiple causes and impacts |
| Critical Thinking | Let students make their own reasoning explicit | Q1In your classroom discussions, teachers always: Encourage you to express your own opinions freely |
| | Let students formulate and exchange personal solutions | Q2 In your classroom discussions, teachers always: Allow you to exchange opinions with other classmates |
| | Let students, during and after the learning activity, reflect on their values and attitude in relation to sustainable development. | Q3 In your classroom discussions, teachers always: Encourage you to think about your own opinions |
| Participation and Collaborative Learning | Let students work together on tasks that are realistic and meaningful for them, in situations where they can act independently. | Q1 For your group/individual assignments, teachers always: Ensure you work together with other classmates on relevant topics |
| | Create learning situations that give students the opportunity to be active in extracurricular contexts and to participate in real-life societal issues related to sustainable development. | Q2 Outside the classroom, school facilities like clubs and workshops often: Promote your engagement in activities outside school like internships/volunteer work |
| | | Q3 Outside the classroom, school facilities like clubs and workshops often: Promote your engagement in activities within school like arts and humanities/natural science competitions, fairs |

| | | |
|---|---|---|
| Action Oriented | Let students conduct action research into a problem that is recognisable, realistic, meaningful and related to sustainability.* | Q1 For your group/individual assignments, teachers always: Allow you to conduct research (eg., data collection, data analysis, evaluating findings) into a recognisable and meaningful problem |
| | Let students link the results of their educational activities (research) to concrete action. | Q2 Outside the classroom, school facilities like clubs and workshops often: Let you link research from class assignments to practical action within/outside school (eg., school improvements, internships/volunteer work) |

** The design principle falls under 'Investigative Attitude' but has been clubbed under under 'Action Oriented' due to overlaps in meaning*

### 3.1.2 Students' Participation in Sustainable Development

As per Table 2, perceived future participation was measured across three categories as discussed in the literature: perceived attitudes, engagement and self-efficacy. Based on literature of perceived attitudes on development issues as seen in Zerihun and Dawit (2024) and others, students were asked to choose one development problem they would find most pressing in the future. Additionally, perceived engagement taken towards issues were also measured using a case-vignette scenario inspired from Holdsworth et al (2018). Their study had more response options, but for the purpose of this study it would reduce options to easier distinguish across four engagement levels. The categories attached to the response options: non-awareness (1), awareness (2), responsibility (3), leadership (4,5). Lastly, inspired by literature from Bandura (1993) student self-efficacy in present skill level to engage with their perceived pressing problem in the future was measured on a Likert scale.

Table 2: Student Perceptions of Future Participation in Sustainable Development Issues

| **Participation Variable** | **Original Literature** | **Repurposed Survey Question** | **Response Options** |
|---|---|---|---|
| Case-Vignette Scenario of Perceived Engagement in Student's Future Workplace | Holdsworth et al (2018) | It's the year 2030 and you land a job at your dream company. You have identified impacts within your company's operations such as excess waste in production and workplace discrimination. However, the business is not largely concerned with these | 1. Do not consider your workplace to negatively impact the environment and/or society<br>2. Be aware of the impacts yourself and let others in the workplace take responsibility for reducing them |

| | | | |
|---|---|---|---|
| | | impacts. How are you most likely to respond? | 3. Tell others in the workplace about the impacts you have identified<br>4. Develop strategies to actively adjust your own practice<br>5. Develop strategies for the workplace and actively support others in the workplace to contribute to them |
| Perceived Attitudes towards Development Issues | Tedeschi et al (2021) | When you think about life after high school, what do you think the world's most pressing problem would be? | 1.Environmental degradation (eg., climate change, loss of biodiversity, excess land use)<br>2.Social injustice/exclusion (eg., gender inequality, poverty, human rights violations)<br>3.Economic instability (eg., inflation, unemployment, recessions)<br>4. Unsure<br>5. Nothing really<br>6.Other: _____ |
| Perceived Self Efficacy* | Bandura (1993) | Do you feel you have the basic skills today to actively engage with the problem in the future? | 1-Not at all<br>2-Slightly<br>3-Moderately<br>4-Very<br>5-Most definitely |

**Follow-up question to "Perceived Attitudes towards Development Issues" only if students' chose either options 1,2,3 or 6.*

### 3.1.3 Other Factors Influencing Students' Perceived Future Participation

In addition to analysing ESD skills on student participation, other factors were also identified from the literature as influencing factors of student participation (Table 3). To account for this, a chosen set of personality traits was measured based on the Big Five children's assessment and select traits linked to SABs (Cupani et.al, 2020; Smith et.al, 2021; Hopwood et.al, 2022) measured on a Likert scale.

Literature had also pointed to the role of parental influence in students perceived future participation in development issues (Schulz et al., 2010; Zukin et al., 2006). The survey hence asked students how much their parents are engaged with the problem they find most pressing. The parent could be working in any profession, the point of interest here was to measure

to what extent they are involved with professional work on the student's perceived problem. This was also measured using a Likert scale.

The last factor investigated was external learning sources used by the student for their school learning such as online courses, non-fiction books, AI tools, etc Scholars have pointed to the role these resources play in enhancing student learning (Abulibdeh et. al, 2024; Khan and Setiawan, 2019; Job and Coleman, 2016). The survey question here therefore attempted to understand which tools students use the most, and whether students mainly utilise online resources, offline resources or a mix of both.

Table 3: Other Factors Influencing Students' Participation

| **Other Factor Variable** | **Original Literature** | **Repurposed Survey Question** | **Response Options** |
|---|---|---|---|
| External Learning Sources | Abulibdeh et. al, 2024; Khan and Setiawan, 2019; Job and Coleman, 2016 | Apart from school material, which sources do you use for your school learning? (Tick all that apply) | 1. Online courses<br>2. Newspapers<br>3. Non-fiction books<br>4. Online news platforms (eg., social media, news apps)<br>5. AI tools (eg., ChatGPT, DeepAI)<br>6. Online search platforms (eg., Google, Bing Search)<br>7. Other: _____ |
| Parental Influence* | Schulz et al., 2010; Zukin et al., 2006 | To what extent does your father work on issues related to the problem?<br><br>To what extent does your mother work on issues related to the problem? | 1-Not at all<br>2-Somewhat<br>3-To a great extent<br>4-Unsure |
| Personality Traits | Cupani et.al, 2020; Smith et.al, 2021; Hopwood et.al, 2022 | Agreeableness<br>1. If a classmate has some difficulty in school, I always help them | 1 – Strongly Disagree<br>2 – Disagree<br>3 – Neutral<br>4 – Agree<br>5 – Strongly Agree |

| | | | |
|---|---|---|---|
| | | 2. I often share my things with classmates<br><br><u>Conscientiousness</u><br>3. I am able to organize my school time well to manage school-related tasks<br><br>4. If I promise my teachers and classmates to complete a task, I will always do it<br><br><u>Openness</u><br>1. I like to know and learn new topics in class<br><br>2. I like to come up with new ideas in class | |

**Follow-up question to "Perceived Attitudes towards Development Issues" (see Table 2) only if students' chose either options 1,2,3 or 6.*

## 3.2 Empirical Design

This section discusses the empirical strategy for addressing the paper's objectives. As discussed in Section 1.4, the paper would like to understand how ESD skills questions are associated with students perceived future participation in sustainable development issues. It aims to do so by firstly using the ESD framework to group students into distinct profiles, and secondly, relating these profiles to the two outcome variables of perceived future participation - perceived future engagement and perceived self-efficacy.

As seen in the previous section, the ESD questions have two distinct features: they are many in number i.e., 12 and are all measured using discrete categories i.e., a Likert scale from 1-Strongly Disagree to 5-Strongly Agree. The perceived participation variables outcome variables are 2 in number and utilise an ordered categorical coding (i.e., low levels of engagement/self-efficacy to high levels). Given this information, the nature of the data becomes paramount in choosing analysis methods to investigate the chosen associations.

Regression analysis has been a commonly used tool in measuring isolated associations between categorical variables and could provide a nascent understanding of existing trends in the data. Hence, the study first proceeds to conduct multivariate regression analysis in an

exploratory fashion between the ESD variables and the perceived participation variables. However, given the potential interconnectedness of the ESD variables – eg. critical thinking questions clubbed under one pillar 'Critical Thinking' (see Table 1) - potential multicollinearity between variables could arise, making it difficult to provide reliable estimates of these associations. The study considers this and interprets output coefficients with caution.

The study aims to go a step further by utilising different analysis techniques to tackle such limitations. For instance, clustering techniques could prove useful as its function is to group data points based on their similarity to show underlying trends in the data, without worrying about high correlations between variables. While many clustering techniques exist, a commonly used technique is K-means clustering (Ikotun et al., 2022). In this study, the technique clusters student responses on ESD skills and perceived participation into different groups based on their likeness.

While clustering is technically possible with 12 ESD variables and 2 perceived participation variables, it would be difficult to visualize and interpret them all together. This is because the K-means clustering output would represent clusters on a 14-dimensional dataset, making it challenging to interpret for an average human. Hence, it is necessary to reduce the number of dimensions to around 2 or 3 dimensions within the dataset, while still retaining the most important information, before establishing clusters. In other words, the primary objective and usefulness of dimensionality reduction is to reduce the complexity of the dataset.

The concept of dimensionality reduction can be illustrated with an intuitive example cited by Flomo (2023). Imagine a complex 3D object such as a human hand. The hand not only contains "base" information like the shape and number of fingers but also "complex" information such as colour, fingerprints, ridges, etc. If the main objective is to find the number of fingers of a hand, most of this "complex" information is not necessary. To reduce the complexity, we can cast a shadow of our hand on a nearby lit wall. Recreating a shadow which best represents our hand involves rotating and reorienting the angle of our hand until we arrive at a high-five gesture. The different angles and orientations which best represent our hand are in this case 'dimensions' which retain the most information about our hand. While this involves a loss of the "complex" information, we still retain enough of the "base" information which can be used in the analysis of how many fingers our hand has.

In real-world datasets with rows and columns, dimensionality reduction techniques such as Principal Component Analysis (PCA) reduce the dimensionality of the dataset while ensuring that most of the variance of the dataset is not lost (Ringnér, 2008). The reduced dimensions called 'principal components' represent the directions along which the variance is maximised. In other words, each dimension represents a combination of all the variables, and measures which variables drive the variance more than others. However, the main assumption of PCA is that variables should be linear. This is because calculations of the principal components are based on linear algebra calculations and are hence recommended to be used with continuous data, as potentially faulty interpretations could arise from using any other data types i.e., non-linear (Mori et al., 2016). A suggested alternative to PCA for this study's type of data which is categorical is Multiple Correspondence Analysis, known as MCA (ibid).

Apart from its dimensionality reduction function, MCA also possesses other benefits attuned to interpretations of categorical data such as graphical visualisations of clouds of datapoints

located close to each other (Hjellbrekke, 2018), making interpretation of correlations between variables more intuitive. Secondly, it can analyse associations between multiple variables at once and does not necessitate assumptions on the data's distribution like linearity used in PCA (Costa et al., 2013). MCA has been used in different social science contexts such as social inequality and pedestrian crashes (Hjellbreke, 2018; Sivasankaran and Balasubramanian, 2020), and in a context similar to this study i.e., measuring associations between university students' higher-order learning and their academic performance (Ogunsakin et.al, 2019). However, a key limitation of the technique is it shows only visual relationships between variables without any clear grouping, potentially leading to faulty and misunderstood interpretations. But in our case, the k-means clustering function helps mitigate this limitation.

As a result, this study uses the dimensionality reduction feature of MCA and the clustering feature of k-means to measure the associations between ESD variables and perceived future participation variables. Arabie and Hubert (1996) suggested a tandem approach to implementing MCA and k-means, which is to first represent the data in a low dimensional space after which cluster analysis is conducted. But Hwang et al. (2006) argued that MCA does not consider the next stage of cluster analysis when reducing dimensions of the data, which could mask the data's most optimal cluster structure. As a result, they introduced a method 'MCA k-means' which ensures both techniques are implemented simultaneously. Due to its efficiency in analysing the data, this study chooses to use the combined technique established by Hwang et. al (2006).

To further inform analysis findings from the main research questions, the study would also like to explore whether trends and relationships with other variables in the survey are observed. Specifically, it aims to understand which problem students find most pressing and external tools they currently use to complement their school learning. Additionally, it aims to understand perceived participation in sustainable development issues across various student's characteristics such as gender, class standard and subject specialisation. This exploratory analysis is conducted to check if other factors apart from the ESD skills could also prove important in shaping students' motivations to participate in sustainable development issues in the future.

Following the rationale behind the choice of methods, the next section aims to provide more details into the processes of the methods, namely the descriptive statistics conducted along with the exploratory multivariate regressions, the dimensionality reduction method "MCA", the clustering technique "K-Means" and the combined algorithm of these two methods finally used in the study – "MCA K-means algorithm".

## 3.3 Analysis Methods

To analyse underlying trends in the study's data and examine its associated research objectives, the study's analysis methods followed the forementioned steps:

### 3.3.1 Descriptive Analysis

This involved a summary of variables in the survey including computation of means, standard deviations, and visual trends of individual variables on their own. Trends for certain individual variables *Personal Attitudes towards Development Issues* (Table 2) and *External Learning*

*Sources* (Table 3) were plotted using pie charts and column graphs, respectively. Differences in means across groups were analysed for the following: 1. perceived self-efficacy across gender 2. perceived engagement levels across class standard and 3. perceived self-efficacy across subject specialisation. Clustered column graphs and Chi squared Tests of Independence were conducted to determine visual trends and statistical significance of group means. The results were extracted using Microsoft Excel, which also acted as the original storage/coding location of the dataset.

As a part of the descriptive analysis, the study also conducted multivariate OLS regressions between the ESD variables and the perceived participation variables to provide a nascent understanding of trends between them in terms of direction and statistical significance. The model specifications for the ESD variables against each outcome variable of perceived participation are enumerated as follows:

$$Y\ (futurework) = \alpha + \ \beta x1 + \ \beta x2 + \ \epsilon \ - (1)$$

$$Y(selfefficacy) = \alpha + \ \beta x1 + \ \beta x2 + \ \epsilon \ - (2)$$

The outcome variable *futurework* in Model 1 is the chosen level of engagement students perceive they would undertake in their future workplace on sustainable development issues. The outcome variable *selfefficacy* in Model 2 shows the chosen level of self-efficacy in their present skills to tackle sustainable development issues in the future. In both equations, $x1$ refers to a vector of all ESD variable questions, $x2$ consists of a vector of student characteristics such as school standard, gender, specialisation and duration of study in school. The regression outputs were extracted using STATA 18.

### 3.3.2 Multiple Correspondence Analysis (MCA)

Multiple Correspondence Analysis (MCA) is a dimensionality reduction technique used to analyse and visualize correlations between numerous categorical variables assigned to individual respondents. In our case, MCA looked at the strength of correlations between students answers to ESD variable questions. For eg., the relationship between students who answer, "Strongly Agree" for the "Student-Oriented" ESD variable and "Strongly Disagree" for the "Critical Thinking" variable. Additionally, the ESD variables were further mapped against perceived participation responses. The resulting output from MCA showed two characteristics:

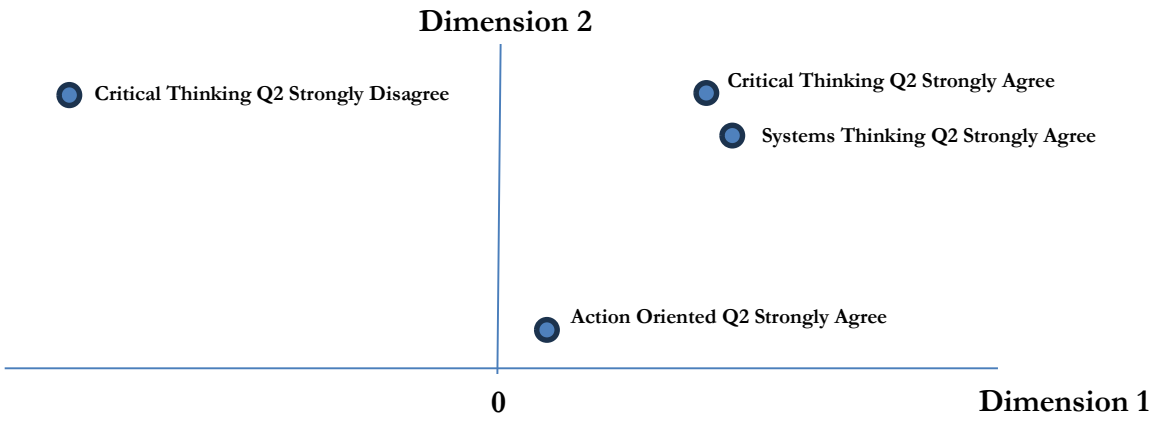
1. *dimensions which explain the most variance in the dataset (on the x and y axes)* – MCA was first used to reduce the number of dimensions from the study variables' dataset to those which explained the most variance or deviation from the expected mean. These dimensions were calculated with a statistical measurement called "inertia" which measured each dimension's contribution to explaining the variance in the dataset. Each dimension's contribution was calculated as a percentage contribution of the inertia value to the total contribution of inertia. This was represented graphically on a Scree plot.

2. *position of the variables and their categories on this lower dimensional space* – Once the main dimensions explaining the variance were calculated, the importance of the ESD variables was

represented graphically as a category plot on a 'low dimensional MCA space' i.e., measuring only 2-3 dimensions explaining the most variance in the data. These variable coordinates were estimated using statistically significant correlation coefficients assigned to each variable. Following interpretations from MCA scholars Parchomenko et al (2019) and Hjellbrekke (2018) among others, MCA indicates that the closeness of variable points to each other show strong associations between them, while further distances from each other implies the opposite. Additionally, if these points are located on opposite sides of a dimension, this implies an opposing relationship between the variables. Finally, variables and their categories located closer to the centre of the dimensions' axes have been argued to represent the average responses of the dataset.

Consider a fictional example from our dataset (Fig.3) to intuitively understand these interpretations. Here we see, Critical Thinking Q2 – Strongly Agree and Systems Thinking Q2 – Strongly Agree are located close to each other on the plot, this would signify a strong association between the two variables and their categories. On the other hand, Action Oriented Q2 – Strongly Agree is located away from the mentioned variables and closer to 0. This implies a lower correlation between this variable and the others, and the variable category chosen the most by students on average. However, Critical Thinking Q2 – Strongly Agree and Critical Thinking Q2 – Strongly Disagree are located on opposite sides of Dimension 1, indicating a negative relationship between these variable categories.

Fig 3: Fictional example of dataset for MCA interpretations




In summary, the MCA plot showcased the association between the study's variables by first reducing the dimensionality of the dataset, after which it analysed and visualised distances between the points in the lower-dimensional space.

### 3.3.3 K-means Clustering

K-means is a clustering method used towards identifying patterns of similarity or dissimilarity in a dataset. Specifically, this method identifies groups that look very similar to each other within the group, but very unsimilar to other groups. The method begins by dividing the dataset based on a predefined set of non-overlapping clusters *k*. It does so by first choosing data points at random = no. of *k* which denote the centroids or midpoints of the clusters.

After which, the method measures the distances between each cluster centroid to the rest of the points closest to it. The method repeats this process multiple times until two criteria are achieved: the distance between the centroid to the rest of the cluster points (intra-cluster) are minimized and the distance between clusters (inter-cluster) are maximized. The number of predefined clusters was chosen based on the Average Silhouette Width (ASW) method. Here, a 'silhouette statistic' is calculated for each observation's fit into their respective cluster. The values for each observation are measured on a range from -1 to 1 and are calculated on average for all clusters. A higher ASW value indicates stronger clustering quality i.e., observations located closer to the centroid of the cluster and away from the rest of the clusters, thereby meeting the criteria of k-means mentioned above. In the context of this study, the students themselves are represented as datapoints in clusters based on their responses to both the ESD questions and perceived participation questions.

### 3.3.4 MCA K-means Algorithm

However, as mentioned in Chapter 3.2, running the MCA and k-means clustering techniques in tandem have been argued to come with a key limitation of masking the most suitable clustering structure for the data. Hence, the study used the MCA k-means algorithm proposed by Hwang et al (2006). It entailed finding the low-dimensional space for the ESD skills and perceived participation variables with MCA, while simultaneously using K-means to cluster groups of students who responded in a similar way to these questions. The algorithm was run twice for the ESD variables with each of the perceived participation variables, respectively.

To implement the algorithm, few parameters needed to be specified apriori such as the number of dimensions (d), the number of clusters (c) and $\alpha_k$ which controls the influence of each method. $\alpha_k = 1$ puts all the influence on the MCA while an $\alpha_k = 0$ puts the influence on the k-means. To ensure equal weighting of both processes, the recommended value of $\alpha_k = 0.5$ was used (Markos et al, 2019; Hwang et al, 2006).

To calculate the optimal combination of d and c, the *tuneclus* function was used. Here, the MCA k-means algorithm was run for various combinations of dimensions ranging from 2-10 and clusters ranging from 3-10. The minimum number of clusters was kept greater than the minimum number of dimensions as suggested by Van Buuren and Heiser (1989), Vichi and Kiers (2001). The optimal number of clusters was determined by the Average Silhouette Width (ASW) method. The optimal number of dimensions was chosen based on rules of thumb indicated by literature such as 1. the cut-off at the elbow in the Scree plot (the dimension at which the line curve begins to flatten) and 2. together, dimensions should explain >70% of the inertia of the dataset (Hjellbreke, 2019; Sourial et. al, 2010).

However, Greenacre (1984) argued that the percentages of the total inertia explained by each dimension in MCA can be underestimated due to overestimation of the total inertia. This could prove problematic as it motivates one to choose more dimensions than necessary (Trujillo-Ortiz, 2024). Hence, a correction to account for this overestimation as suggested by Greenacre (1984) was also used.

The final outputs of the algorithm included:

- MCA-kmeans plot which combined the results of both the MCA plot and the k-means clustering results. It showcased the contribution of the ESD variables, perceived participation variables and their respective Likert scale categories on the MCA dimensional space, and student clusters based on responses to the variable questions.

- Means tables of student clusters which show their means and standard deviations of ESD variables and each perceived participation variable, respectively.

The algorithm was run using the software RStudio Version 2024.04.2+764. The packages *clustrd* in R developed by Markos et. al (2019) was used for analysis and visualisations. The *matplotlib* package in Python 3 was also used in the creation of visualisations.

# Chapter 4
# Results

## 4.1 Descriptive Analysis

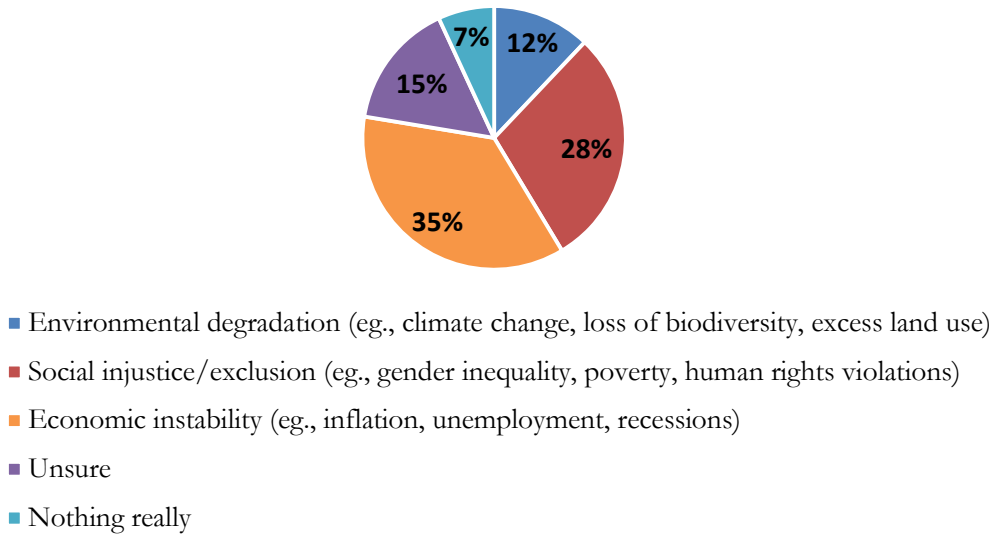
This subsection provides the first stage of the study's analysis: a description of the variables and a trends analysis of selected variables. Table S4 found in Annex D represents the summary statistics of the entire survey data. The total sample for the study was n = 60 high school students. Most of the students belonged to the 10th standard (46.6%), followed by 11th and 12th standards. The number of males and females were equally represented, with most of the students studying in the school since kindergarten. Students mostly reported positive personality traits, with parental influence appearing mixed between "somewhat" and "to a great extent".

Before exploring the key research objectives, the study first investigated certain variables frequency counts and their relationships with student characteristics through descriptive analyses:

1. Students' attitudes towards sustainable development issues

As a first step to understanding students perceived future participation in sustainable development issues, attitudes of students were first measured via their perceptions of the world's most pressing development problem (Fig.4). Most students in this school sample indicated that economic instability was a worry followed by social injustice. Students also expressed uncertainty on the question (15%) and environmental degradation was reported as an issue by 12% of students. This result shows a clear variation in responses towards their perceptions on the world's most pressing problem.

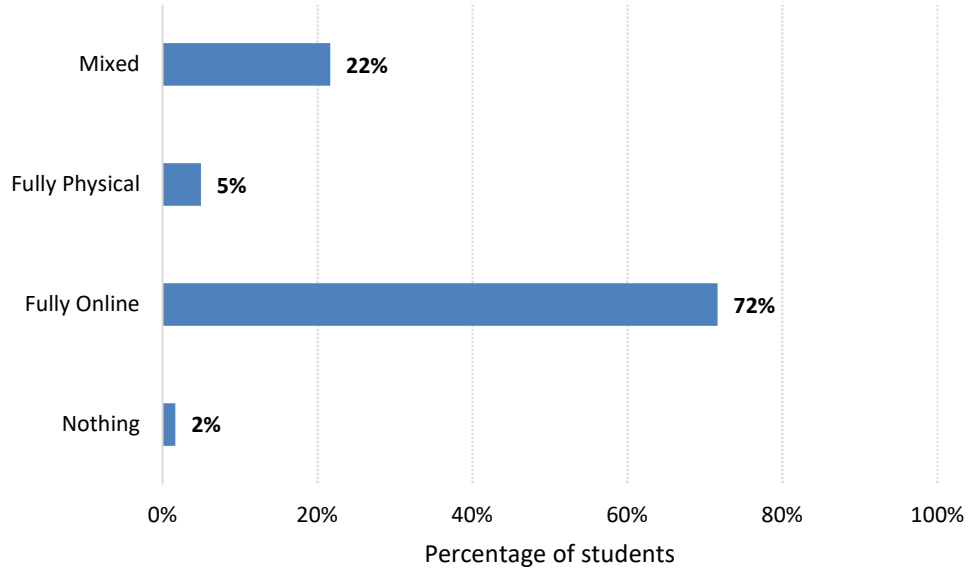
Fig.4. Students' perceptions on the worlds most pressing problem



2. Students external learning tools to complement school learning

Analysing the students' usage of external platforms for school learning (Fig.5)., most students reported the use of completely online tools such as online courses, AI tools, search engines and news apps/social media. This was followed by 22% who reported using a combination of both online tools and traditional tools such as non-fiction books, guide books and newspapers. This result indicates a clear inclination of students towards the usage of online tools to complement their school learning.

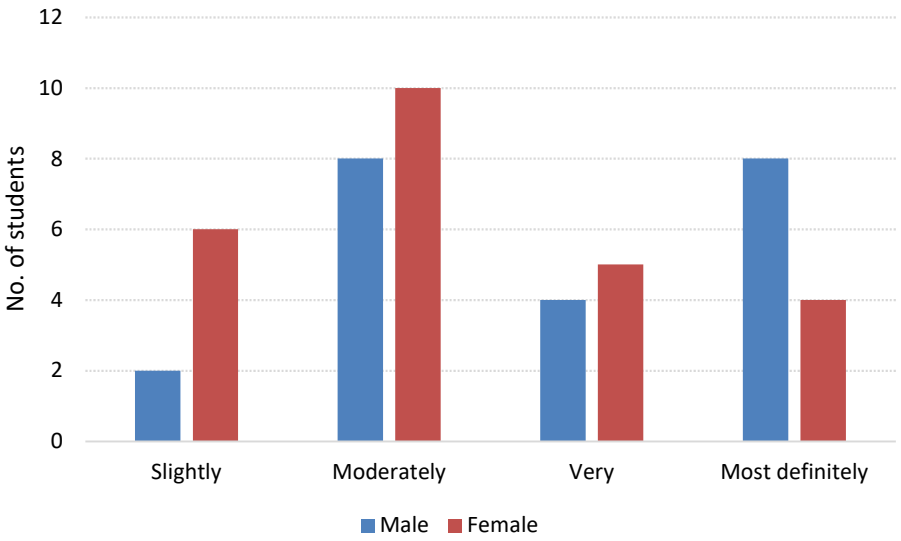
Fig.5. Students' usage of external platforms for school learning




3. Perceived participation in sustainable development issues across student characteristics

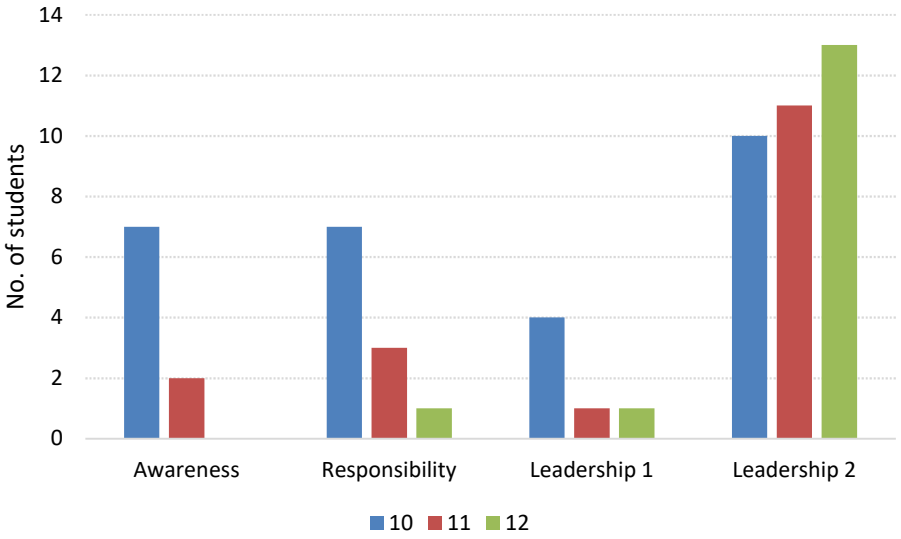
Fig. 6 below represents perceived self-efficacy of skill levels among the students. It was observed here that more female students reported low and moderate levels of perceived self-efficacy compared to male students. More male students also reported the highest level of self-efficacy in relation to female students. Albeit the finding was not statistically significant as per the Chi Squared test (chi2 = 3.49; Pr = 0.322). In any case, this finding could show a preliminary trend in gender differences on self-efficacy in skill levels to tackle sustainable development issues in the future.

Fig.6. Students' perceived self-efficacy levels across gender



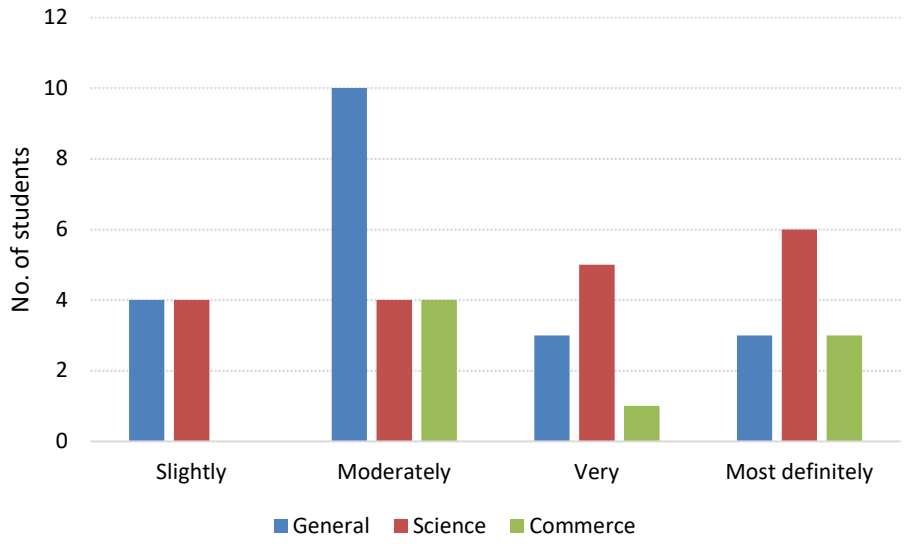

On looking at trends in perceived engagement levels in their future workplace across class standard (Fig. 7), the analysis found more 10th standard students reported lower levels of engagement than 11th and 12th standard students. 12th standard students reported the highest level of perceived engagement in their future workplace relative to the lower standards. The trend appeared to be statistically significant at the 10% level as per the Chi Squared test (chi2 = 11.7467; Pr = 0.068). This could indicate that students who are older perceive themselves to have more agency in engaging with sustainable development issues actively in their future workplace. Such trends are expected as relatively older students have perhaps developed more confidence and purpose in their ability to undertake the highest forms of leadership in their future workplace setting.

Fig.7. Students' perceived engagement levels in future workplace across class standard



Lastly looking at trends in perceived self-efficacy across specialization in Fig. 8, more 10th standard students* reported lower levels of self-efficacy than 11th and 12th standard students, like findings on their perceived engagement levels. Also, 11th and 12th standard students belonging to the science specialization reported the highest levels of self-efficacy in comparison to other specializations. However, the trend is not found to be statistically significant (chi2= 6.5879; Pr = 0.361) Regardless, this result shows a potential difference within the learning environment of the science stream students vs commerce and general streams.

Fig.8. Students' perceived self-efficacy across specialization stream




**Note: all 10th standard students belong to the General specialization, with 11th and 12th standard students opting between Science and Commerce*

### 4.1.1 Multivariate Exploratory Regressions

The results from Table 4 provides the regression estimates of the ESD variables regressed over the perceived participation variables, with standard errors in parentheses. The output from Model (1) shows the associations between ESD variables against the *futurework* variable. Here, it can be observed that the ESD variables along with the student characteristics variables explain 46% of the variation in students' perceived engagement levels towards sustainable development issues.

Additionally, the question on Systems Thinking 2 appears to have a positive statistically significant trend (at the 10% level) in students perceived engagement levels. In other words, students who perceive that teachers allow them to analyse problems with multiple causes and impacts in group/individual assignments also perceive higher levels of engagement in sustainable development issues in their future workplace. School standard also appears to play a similar role in higher levels of engagement (significant at the 5% level), also seen with Chi squared tests and visualisations presented in Section 4.1, Fig. 6.

Table. 4 OLS regression estimates of ESD variables and perceived participation variables
Standard Errors are depicted in parentheses. * p<0.1, ** p<0.05 , *** p<0.01

| **ESD variables** | **Perceived Participation** | |
|---|---|---|
| | (1) futurework | (2) selfefficacy |
| Student Oriented Q1 | -.037 | -.133 |
| | (.266) | (.289) |
| Student Oriented Q2 | .229 | .146 |
| | (.227) | (.246) |
| Systems Thinking Q1 | -.017 | .031 |
| | (.19) | (.195) |
| Systems Thinking Q2 | **.472*** | .088 |
| | **(.272)** | (.282) |
| Critical Thinking Q1 | .109 | -.355 |
| | (.232) | (.336) |
| Critical Thinking Q2 | -.027 | -.166 |
| | (.226) | (.263) |
| Critical Thinking Q3 | .044 | .422 |
| | (.237) | (.307) |
| Participation, Collaboration Q1 | -.36 | .222 |
| | (.23) | (.266) |
| Participation, Collaboration Q2 | -.132 | .397 |
| | (.27) | (.295) |
| Participation, Collaboration Q3 | .12 | -.239 |
| | (.203) | (.221) |
| Action Oriented Q1 | .065 | .042 |
| | (.237) | (.277) |
| Action Oriented Q2 | -.003 | -.062 |
| | (.26) | (.293) |
| **Student characteristics** | | |
| School Standard | **.816**** | .575 |
| | **(.387)** | (.449) |
| Gender | .147 | **.882**** |
| | (.314) | **(.364)** |
| Specialisation | -.397 | -.131 |
| | (.441) | (.498) |
| Duration in School | .236 | .268 |
| | (.164) | (.201) |
| Constant | 1.198 | .409 |
| | (.802) | (1.077) |
| Observations | 60 | 47 |
| R-squared | .461 | .444 |

In Model (2), the ESD variables along with the student characteristics variables explain 44% of the variation in students perceived self-efficacy levels towards engagement in sustainable development issues. While the estimates of the ESD variables in this model do not show statistical significance, nascent trends could be extrapolated from the estimates with lower standard errors. For instance, the 'Participation and Collaboration' questions show positive slopes with lower standard deviations, showing a potential inclination towards positive significance. The variable gender in this model was found to be statistically significant at the 5% level towards self-efficacy, which notably shows contrasting results to those found in Chi squared tests and visualisations in Section 4.1, Fig. 5.

Given the OLS data transformation from categorical to continuous, potential level of multicollinearity amongst ESD variables, and lower sample size, the results of the OLS regression outputs in Table 4 are interpreted with caution and only proceed to give us a nascent idea of the trends between the ESD variables and the perceived participation variables.

Building on these regression results, the next subsection highlights the use of the MCA-k means analysis technique to investigate the associations between ESD variables and perceived participation variables, while mitigating some of the limitations arising from the regression outputs.

## 4.2 MCA K-means Clustering

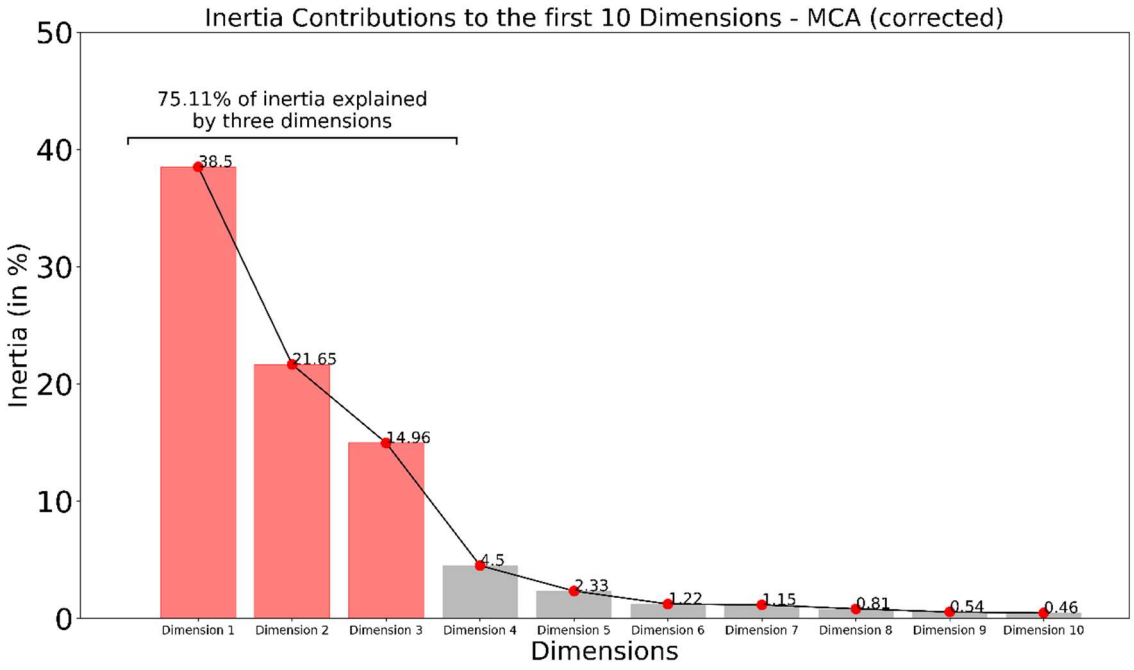
The next stage of the study's analysis will explore the main research questions on the ESD survey questions and its associations with key variables: perceived engagement levels in a future workplace and perceived self-efficacy.

### 4.2.1 Optimal number of dimensions (d)

To obtain the number of dimensions, the inertia explained by the dimensions (absolute values and percentage of total inertia) are calculated which is tabulated in annex C. It has also been visually represented with a Scree plot (Fig. 9). The Scree plot is used to represent the contribution of each dimension to the total inertia of the dataset. A correction as suggested by Greenacre (1984) was made to account for the overestimation of the total inertia that occurs with MCA.

It was observed that the first 3 dimensions contributed 75.11% of the variability in the dataset (Fig. 9 red bars). As per the criteria recommended by literature mentioned in Section 3.3.4, three dimensions (d = 3) were chosen, but the first two dimensions were chosen for visualisations due to easier interpretation.

Fig.9. Scree plot of dimensions contribution to inertia of dataset




### 4.2.2 Optimal number of clusters (c)

After choosing d, the number of clusters (c) needs to be determined. The number of c is defined by the following criteria: (1) c>d as recommended by Van Buuren & Heiser (1989), Vichi & Kiers (2001), and (2) The Average Silhouette Width (ASW) should be at its maximized value. Using the *tuneclus* function in R, it was determined that 4 clusters were the best fitted to the data, given the criteria mentioned above.

The function *clusmca* in the package *clustrd* was used for implementation of the MCA k-means algorithm, c and d were specified as the number of clusters and number of dimensions respectively. As mentioned in section 3.3.4, the parameter $\alpha_k$ was set to 0.5 to establish equal importance to both methods.

### 4.2.3 Output of MCA k-means - category plots and means tables

The main output of the MCA k-means algorithm called a category plot involved a graphical display in which the variables coordinates of the ESD variable categories and perceived future participation categories were plotted on the low dimensional MCA space i.e., the chosen dimensions explaining the most variance in the data represented on the plot axes. As part of the MCA technique, it provides a visual overview of how these variables relate to each other. For easier interpretation, the plot only uses the first two dimensions. As part of the k-means technique, student clusters based on their categorical responses to the ESD questions and perceive participation questions were simultaneously plotted on the two-dimensional MCA plot. These student clusters are also represented in cluster maps[5] shown in Annex E.

[5] Cluster maps for each student cluster represent standardized residuals (deviation of the observed frequency from the expected mean i.e., 0) of the top 20 categories of all variables. Larger positive deviations of variable categories from 0 indicating greater frequencies of that response to the cluster while a large negative deviation indicates a lower frequency contribution to the cluster.

While the MCA-kmeans category plots provide a visual understanding of the associations between variables and between student clusters, it does not provide a clear grasp of the numerical associations between ESD variables and perceived participation variables. Hence, the study also analyses differences in means across student clusters calculated from the MCA-kmeans analysis. The results to follow include the MCA-kmeans category plots and means tables respectively, for our two associations of interest - ESD variables and perceived engagement levels, ESD variables and self-efficacy levels.

ESD variables and Perceived Engagement

Fig. 10 represents the category plot for ESD variable categories and perceived engagement variable categories, along with associated student clusters. First, we see that the ESD variable categories on the Likert scale separate into groups across Dimension 1. The 'Strongly Agree' categories are located close to each other (on the top rightmost quadrant), indicating strong correlations within these categories. The 'Strongly Disagree' categories on the other hand, while located in proximity to each other, are located on the other side of Dimension 1 (the top leftmost quadrant). Location of variable categories at opposite ends of a dimension implies these categories strongly differ from each other (Hjellbrekke, 2018). Logically, this makes sense considering these are two extreme responses on the Likert Scale. Moreover, we observe the 'Agree' categories at the bottom rightmost quadrant, close to the center of the axes. As we recall from Section 3.3.2 on the MCA interpretation, "*variables and their categories located closer to the centre of the dimensions axes have been argued to represent the average responses of the dataset"*. This implies that most responses towards ESD questions have been 'Agree'. It is also notable here that the MCA cannot seem to distinguish between response options 'Neutral' and 'Disagree' (bottom leftmost quadrant) with a clear overlap in these categories.

As of now, we understand the split of the variable categories and its significance but are still yet to determine how many students belong to each split. To uncover this, the category plot also includes student clusters based on their responses to the ESD and each perceived participation question. In Fig.10, we observe that student clusters (like the variable categories) are separated across the four quadrants of the plot based on their responses to the ESD variable questions and the question on perceived engagement level in a future workplace.

Cluster 1 (red) appears to be the largest cluster followed by Cluster 2 (green), Cluster 3 (blue) and finally Cluster 4 (purple). Cluster 1 appears to be closer to the plot origin and has mostly answered 'Agree' to the ESD questions. As seen previously, this implies that most students in the sample have positive perceptions of their ESD skills learning in school. Cluster 2, the second largest student cluster, can also be compared with Cluster 4, the smallest student cluster. Both the clusters show different ESD variable categories associated with them with 'Strongly Agree' for Cluster 2 and 'Strongly Disagree' for Cluster 4. These clusters are located on opposite sides of Dimension 1 just like the variable categories, implying these groups of students are starkly different from each other.

Overall, results from the clustering exercise have identified 4 distinct groups, with profiles ranging from "Strongly Agree" to "Strongly Disagree" (Fig.10, Table 5). These profiles show consistent patterns in the ESD variables as well as the perceived future engagement variable. The interpretations of each student cluster follow the displayed figure and table.

Fig. 10 MCA-kmeans category plot (ESD variables, Perceived Engagement, student clusters)

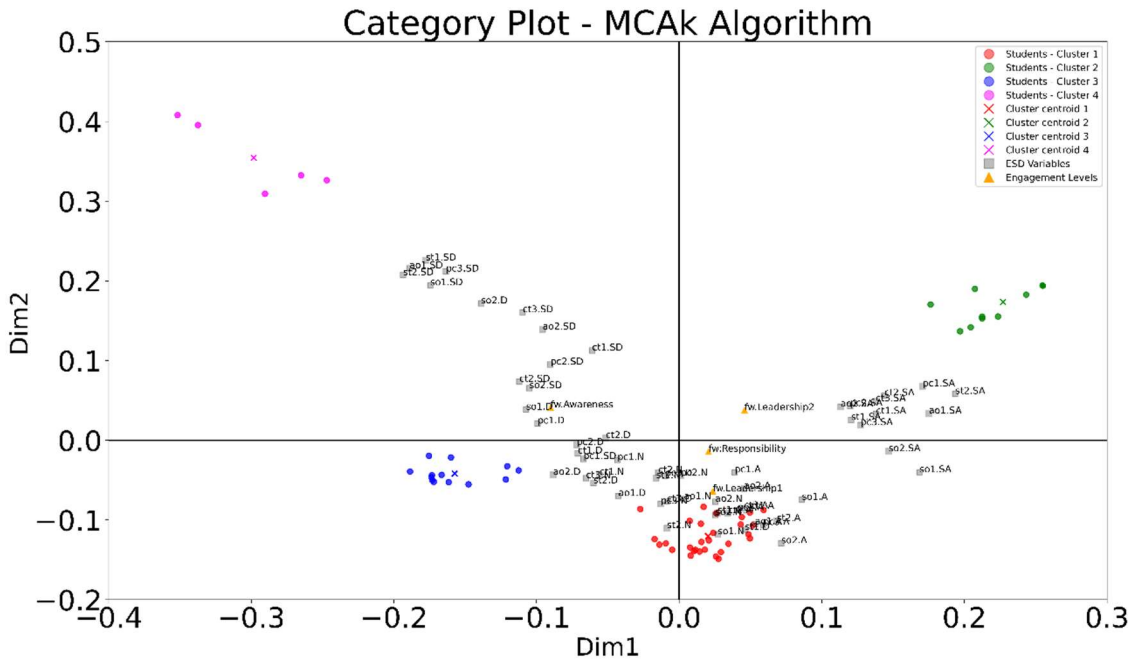



Table. 5 Means and standard deviations of student clusters (ESD variables and perceived engagement variable)

| Variable Name | Cluster 1 Agree Choosers (n = 29) | | Cluster 2 Strongly Agree Choosers (n = 13) | | Cluster 3 Neutral/Disagree Choosers (n = 13) | | Cluster 4 Strongly Disagree Choosers (n = 5) | |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| **so1** | 3.7 | 0.7 | 4.2 | 0.7 | 3.1 | 0.5 | 2.8 | 1.3 |
| **so2** | 4.1 | 0.6 | 4.6 | 0.8 | 3.2 | 1 | 2.8 | 1.6 |
| **st1** | 3.9 | 0.7 | 4.6 | 0.8 | 3.5 | 0.8 | 2 | 1.4 |
| **st2** | 3.5 | 0.6 | 4.7 | 0.5 | 2.7 | 0.5 | 2.2 | 1.3 |
| **ct1** | 3.8 | 0.9 | 4.5 | 1 | 2.5 | 0.8 | 1.8 | 0.8 |
| **ct2** | 3.6 | 1 | 4.6 | 0.8 | 2.5 | 1 | 1.4 | 0.6 |
| **ct3** | 3.8 | 0.7 | 4.5 | 1.1 | 3 | 0.9 | 1.4 | 0.9 |
| **pc1** | 4 | 0.5 | 4.7 | 0.5 | 2.7 | 0.9 | 3.4 | 0.9 |
| **pc2** | 3.7 | 1.1 | 4.5 | 1 | 2.5 | 0.9 | 1.2 | 0.5 |
| **pc3** | 4 | 0.8 | 4.6 | 0.9 | 2.9 | 0.9 | 1.8 | 1.8 |
| **ao1** | 3.6 | 0.7 | 4.6 | 0.7 | 3 | 0.9 | 2.6 | 1.1 |
| **ao2** | 3.6 | 1 | 4.2 | 1.2 | 2.5 | 1 | 1 | 0 |
| **futurework** | **4.0** | 1 | **4.8** | 0.6 | **3.9** | 1.5 | **3.4** | 1.5 |

**Cluster 1 – 'Agree' Choosers**

As per Table 5, Cluster 1 represents the cluster with the most students (48.3%) in the dataset. It mainly consists of students who chose 'Agree' on the ESD variables. In other words, students agree that their school encourages collaborative learning through group project work with classmates and participation in school activities such as competitions/fairs (pc1, pc3), a teacher pedagogy which teaches with recognizable and meaningful examples (so2), critically being able to express and exchange your own opinions with other classmates (c1, c3), conducting research into a meaningful problem (ao1) and being taught and encouraged to use systems thinking (st1, st2). However, standard deviations for some of the mean values remain high, implying some students chose neutral or strongly disagree for some ESD variables. For example, linking research conducted in class to practical action (ao2), reflecting on opinions in class (c2) and participation in external activities like internships/volunteer work (pc2) showed high standard deviations of 1 or more.

Overall, students on average who chose 'Agree' on these ESD variables also perceived themselves to take on a high level of engagement, i.e., option 4 in the engagement question - make changes to their own work practices to curb their future workplace impacts on sustainable development issues (Table 5). Notably, the corresponding cluster map showed students also answered option 3 – telling others in the workplace about impacts identified – although to a lesser extent (*Annex E – Fig. S1*).

**Cluster 2 – 'Strongly Agree' Choosers**

Cluster 2 (21.7%) represents the second largest cluster in the dataset (Table 5). As per the table, it is mainly characterized by students who 'strongly agree' that their school encourages and teaches systems thinking (s1, s2), encourages conducting research into a problem and linking it to practical action (ao1, ao2), critically being able to express, reflect and exchange your own opinions with other classmates (c1, c2, c3), collaborative learning through group project work with classmates and participation in school activities such as competitions/fairs and external activities like internships/volunteer work (pc1, pc2, pc3), a teacher pedagogy which accounts for prior knowledge of concepts and teaches with recognizable and meaningful examples (so1, so2). Also, large standard deviations were obtained for some ESD variables, alluding to mixed student responses.

Notably, students on average who 'Strongly Agree' on these ESD variables also perceived themselves to take on the highest level of engagement in their future workplace on average i.e., option 5 in the engagement question (Table 5). This means that students who 'Strongly Agree' on ESD variables in school also desire to develop strategies for their future workplace to curb its negative impacts towards sustainable development issues. Such findings were also presented in the respective cluster map (*Annex E – Fig. S2*).

**Cluster 3 – 'Neutral'/ 'Disagree' Choosers**

Cluster 3 (21.7%) also represents the second largest cluster in the dataset. It is mainly characterized by students who either 'Disagree' or are 'Neutral' that their school encourages conducting research into a problem and linking it to practical action (ao1, ao2), encourages and

teaches systems thinking (s1, s2), collaborative learning through group project work with classmates and participation in school activities such as competitions/fairs and external activities like internships/volunteer work (pc1, pc2, pc3), critically being able to express, reflect and exchange your own opinions with other classmates (c1, c2, c3), a teacher pedagogy which accounts for prior knowledge of concepts and teaches with recognizable and meaningful examples (so1, so2). This can be observed with a mean range of 2-3 in Table 5 implying students mix in response categories of disagree and neutral.

Students who picked these variable categories also perceived themselves to take on the lowest reported level of engagement in their future workplace. In other words, these students chose to be aware of the negative impacts but let others in the workplace take responsibility for reducing them. But on average, this group reported a higher engagement level than Cluster 4 – the 'Strongly Disagree' Choosers (3.9 vs. 3.4).

**Cluster 4 – 'Strongly Disagree' Choosers**

Cluster 4 (8.3%) represents the smallest cluster in the dataset. It is mainly comprised of students who 'Strongly Disagree' that their school encourages collaborative learning through group project work with classmates and participation in school activities such as competitions/fairs and external activities like internships/volunteer work (pc1, pc2, pc3), encourages and teaches systems thinking (s1, s2), conducting research into a problem and linking it to practical action (ao1, ao2), critically being able to express, reflect and exchange your own opinions with other classmates (c1, c2, c3), a teacher pedagogy which accounts for prior knowledge of concepts and teaches with recognizable and meaningful examples (so1, so2).

Like Cluster 3 findings, students who picked these variable categories also perceived themselves to take on the lowest reported level of engagement in their future workplace. In other words, these students chose to be aware of the negative impacts but let others in the workplace take responsibility for reducing them.

Overall, Table 5 of means across student clusters from the MCA-kmeans clustering technique shows varying associations between student perceptions of ESD skills learning in schools and their perceptions of future engagement in the workplace on sustainable development issues. For instance, Cluster 2 – 'Strongly Agree' Choosers and Cluster 4 – 'Strongly Disagree' Choosers showed wide differences in mean perceived engagement levels (4.8 vs. 3.4). This showcases that students perceptions on ESD skills in school differ, and these differences in perceptions also result in different perceptions on perceived engagement levels. Similar mean variations were also observed in engagement levels between Cluster 1 – 'Agree Choosers' and Cluster 4 – 'Strongly Disagree' Choosers (4 vs. 3.4).

A stark observation to note is that the lowest reported engagement level was found to repeat across student Cluster 3 ('Neutral'/'Disagree' Choosers) and student Cluster 4 ('Strongly Disagree' Choosers) (*Annex E – Fig. S3 and Fig. S4*). This could mean that students who reported low engagement levels provided a mix of low category responses to the ESD variables i.e., Neutral, Disagree and Strongly Disagree. As a result, the clustering technique was unable to distinguish responses in these student clusters clearly.

ESD variables and Perceived Self-efficacy

Conducting the same analysis instead on perceived self-efficacy, the ESD variable categories successfully clustered into the same 4 categorical groups as seen with the sample for the engagement variable (Fig.11). However, the student means on the ESD variables for each cluster in Table 6 slighly differ from those of Table 5 due to a reduced student sample for the self-efficacy question alone (*Section 3.1.2 – Table 2*).

Visually, the categories of perceived self efficacy fail to show any clear trends amongst the student groups, with the exception of one category 'Slightly' (Fig.11). As we can see, students answering this category also answered 'Strongly Disagree' to the ESD questions i.e., Cluster 4. Students in this cluster reported a low average mean value of 2.5 on the perceived self-efficacy question versus those in Cluster 2 (Table 6).

As per Table 6, Cluster 4 represents the smallest percentage of the sample (8.5%). It is mainly characterized by students who 'Strongly Disagree' on the ESD indicators of school learning. Students who picked these variable categories reported a low perceived self-efficacy level in their present skill level to tackle sustainable development issues in the future. These findings were also established in the cluster map analysis *(Annex E – Fig. S5).*

But it also shows minimal differences between Clusters 1 and 3 on the perceived self efficacy question. This could perhaps be due to the smaller student sample size n = 47 for this question (*Appendix D – Table 4*). While the clustering technique does not seem to capture all cluster differences effectively, it does show a promising trend of low perceived self-efficacy tied to poor perceptions of ESD skills delivery in schools.

Fig. 11 MCA-kmeans category plot (ESD variables, Perceived Self-efficacy, student clusters)

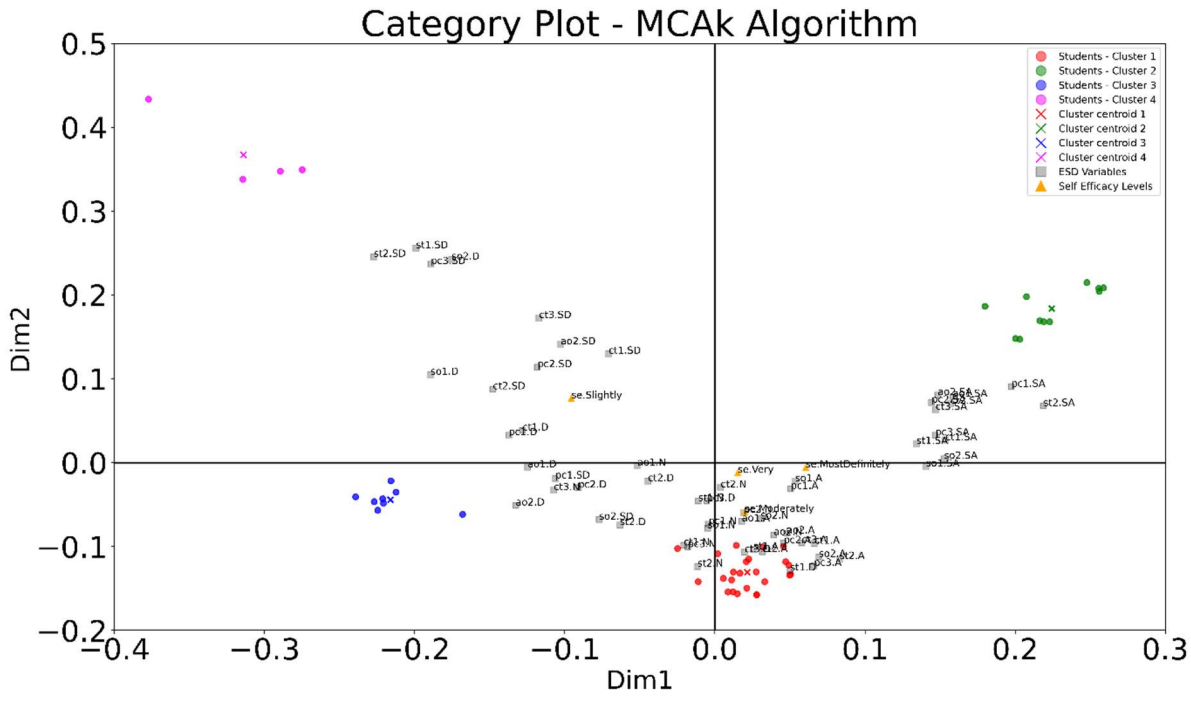


Table. 6 Means and standard deviations of student clusters (ESD variables and perceived self-efficacy variable

| Variable Name | Cluster 1 Agree Choosers (n = 24) | | Cluster 2 Strongly Agree Choosers (n = 11) | | Cluster 3 Neu-tral/Disagree Choosers (n = 8) | | Cluster 4 Strongly Disagree Choosers (n = 4) | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** | **Mean** | **Std. Dev.** |
| **so1** | 3.7 | 0.8 | 4.2 | 0.8 | 3 | 0.5 | 3.3 | 1 |
| **so2** | 4.2 | 0.6 | 4.6 | 0.8 | 3.1 | 1.1 | 3.3 | 1.5 |
| **st1** | 3.9 | 0.8 | 4.6 | 0.8 | 3.5 | 0.8 | 2.3 | 1.5 |
| **st2** | 3.5 | 0.7 | 4.7 | 0.5 | 2.6 | 0.5 | 2.5 | 1.3 |
| **ct1** | 3.9 | 0.8 | 4.5 | 1.2 | 2.5 | 0.9 | 1.5 | 0.6 |
| **ct2** | 3.6 | 1 | 4.6 | 0.8 | 2.3 | 1.2 | 1.3 | 0.5 |
| **ct3** | 3.8 | 0.7 | 4.5 | 1.2 | 3 | 1.1 | 1.5 | 1 |
| **pc1** | 4 | 0.5 | 4.7 | 0.5 | 2.4 | 0.9 | 3.5 | 1 |
| **pc2** | 3.5 | 1.2 | 4.5 | 1 | 2.1 | 0.4 | 1 | 0 |
| **pc3** | 3.9 | 0.8 | 4.6 | 0.9 | 2.8 | 0.7 | 2 | 2 |
| **ao1** | 3.8 | 0.7 | 4.6 | 0.7 | 2.9 | 0.8 | 3 | 0.8 |
| **ao2** | 3.5 | 1 | 4.3 | 1.3 | 2 | 0 | 1 | 0 |
| **Self-Efficacy** | **3.5** | 0.9 | **4** | 1.1 | **3.4** | 1.2 | **2.5** | 1 |

# Chapter 5
# Discussion

## 5.1 Comparison with existing studies

This paper investigated the associations between higher order cognitive skills through the ESD framework and perceived future participation in sustainable development through students' engagement in their future workplace and their perceived self-efficacy. While previous studies have explored the benefits of ESD skills in a qualitative fashion (Laurie et.al, 2016) and predominantly in a university context (Biasutti and Surian, 2012; Valderrama-Hernández et al., 2020), studies have not explicitly attempted to quantitatively measure these metrics in a high school setting in India and analyze its associations to students perceived future participation in sustainable development issues. The study found clear associations between students' perceptions of ESD skills learning in schools and their perceived future engagement in their workplace on sustainable development issues. The use of the MCA and K-means technique as suggested by Hwang et.al (2006) for analyzing complex categorical data was useful in assessing these associations.

The study found students who positively perceived themselves to be receiving higher order cognitive skills through their school pedagogy and facilities also reported the highest levels of future engagement in sustainable development issues in the future. This could infer that students feel more confident to undertake the highest leadership abilities in the future partly due to the higher order cognitive skills learning they receive in present day at school. These results corroborate findings by Schulz et.al (2016) who found that students' involvement in practical school learning and activities contributed positively to their expected future participation in world development issues.

Conversely, the lowest perceptions of ESD skills amongst students were associated with their lowest level of engagement in their future workplace i.e., mere awareness and letting others take responsibility for dealing with the workplace impacts. Notably, this finding was among 'Disagree', 'Neutral', and 'Strongly Disagree' choosers on ESD skills learning in schools. This may imply that students who are agnostic or negatively perceive their school in delivering ESD skills also show an inclination towards less engagement in future workplace issues on sustainable development. Additionally, students did not pick the lowest option in the survey, which was 'Non-awareness' i.e, not considering the impacts to negatively affect the workplace at all. So, it is unclear whether this option could have instead been associated with the 'Strongly Disagree' choosers on ESD skills learning in schools. It may have been that students wanted to provide more "socially desirable" answers as typically found in self-reported surveys (Teh et al., 2023).

Lastly, the 'Agree' choosers expressed higher levels of engagement in solving sustainable development issues in their future workplace by either desiring to tell colleagues about the impacts they identify (*responsibility category*) or make changes to their own work practices (*leadership category*). This could suggest that there is an interconnectedness between the 'responsibility' category and the 'leadership' category, a possible limitation when measuring engagement levels despite it being taken from Holdsworth et. al (2018) who used these categorizations. But since most students in the sample belong to this cluster, we can argue the school has been successful in positively influencing students' perceptions on ESD skills learning and future engagement activities.

Adding to existing literature which measures the relationship between self-efficacy and higher order thinking skills (Leng et. al, 2020; Liu et al., 2024), this study also found associations between perceived self-efficacy and ESD skills, although only at the lowest level. Students who possessed strong negative opinions towards ESD skills learning through school also showed a low perceived self-efficacy in their own skills to tackle sustainable development issues in the future. This could potentially have linkages to students' low perceived engagement levels, with literature showing that having greater self-efficacy in one's own actions lead to higher motivations to undertake those actions (Bandura, 1997), even in the field of environmental sustainability (Schutte and Bhullar, 2017).

Other descriptive analyses from the survey data also yielded insightful results. Most students picked economic instability as a key issue they find most pressing for the world's future. The topic could be one that is very prominent in general with potential links to higher unemployment rates in the country (Forbes India, 2024) with an education-skills mismatch adding fuel to the fire (ILO and IHD, 2024). In other words, students are potentially graduating out of educational institutions without acquiring the practical skills needed to secure a professional job. Such job skills include "data skills" along with higher-order skills like critical thinking and collaboration, with more than 80% of Indian employees in India on average touting their importance in the work economy for the next five years (Statista, 2023). This study found that most students in the school are utilizing online tools such as e-learning courses, social media/news apps and AI tools for school learning, showing the eagerness of students to embrace technology from a young age.

While most literature points to gender and age differences in academic self-efficacy (Mozahem et. al, 2020; Mamnoun et. al, 2023), this study provides nascent trends of differences in students perceived self-efficacy towards their skills in tackling development issues in the future. It found that older students in the 12$^{th}$ standard belonging to the science specialization stream show higher levels of self-efficacy than their counterparts.

## 5.2 Implications/Recommendations from the results

Findings from this study provide the following policy implications to the observed school. Results showed that most students from the school agree that they largely receive ESD skills learning through their school pedagogy and facilities, and further association was found to their active perceived engagement on sustainable development issues in a future workplace. Considering this school belongs to an education board characterised by rote learning traits i.e., State Board, the findings provide an interesting contrast from what we would expect. Perhaps this indicates that despite the nature of the education board, students' perceptions of the school's delivery in these skills seems to have a strong effect on their motivations in the future.

With that said, a minority of students still showed negative perceptions towards both ESD skills learning and perceived future engagement (Cluster 3 and Cluster 4), highlighting that perceptions of a dearth in higher order skill learning in school could play a demotivating role in students' future engagement with sustainable development issues. In summary, not all students perceived learning ESD skills through their school's present pedagogies and facilities.

While it is difficult to know the root causes of this trend, the school could attempt to impart positive perceptions of their pedagogies and facilities to these students to integrate them with those students reporting positive perceptions overall i.e., Cluster 1 and Cluster 2. The school could undertake this by formally implementing or making explicit certain ESD educational practices in pedagogy and facilities linked to ESD higher order skills. Some of these practices could include:

1. **Innovative pedagogies** in the classroom like "problem-based learning" wherein students are asked by teachers to work on solving open-ended real-world sustainable development problems as part of their classroom activities. This could enhance students' critical thinking and problem-solving skills.
2. **Interdisciplinary assessments** through projects and/or assignments which combine perspectives from two or more subjects within the assessment output. Using this criterion for assessments could improve students' systems thinking abilities.
3. **Collaborations between the school and industry stakeholders** such as local companies and governmental organisations to enhance students' collaborative spirit and understanding of sustainable development issues and practical impacts. These tie-ups could include internships, volunteer work and apprenticeships.
4. **Use of technology** to develop educational resource repositories between students and teachers and analytics to measure higher order learning skills among other learning outcomes from courses. Considering most students in this study reported a strong usage of online resources for school learning, the school could perhaps tap into this avenue of learning engagement.

These initiatives have broadly been implemented around the world, but such initiatives have also been recommended specifically towards re-envisioning Indian schools in adopting a more "competency-based" style of education as against its current rote learning approach (Guha Majumdar, 2019). In summary, by advocating these educational practices, the school could ensure a greater number of positive student perceptions in ESD skills learning potentially resulting in their active engagement on sustainable development issues in the future.

The study argues these implications and recommendations possess internal validity towards the sample school and potentially other State Board schools in Chennai operating with a similar setup. Furthermore, cross-comparison studies could also be conducted across schools of this nature to analyse similarities and/or differences in responses. On the other hand, external validity to other State Board schools in India may be more difficult to extrapolate, as different states possess varying characteristics in curriculum and pedagogies within their respective boards.

While recommendations targeted towards the school are crucial, the study's use of a perception-based survey tool could have larger policy implications for assessing progress on India's education policy. Utilising the design of the ESD framework could prove useful in designing standardized quantitative indicators for monitoring the NEP with respect to higher order skills and participation in sustainable development issues. At a country level, these indicators could also contribute to bridging the global measurement gap challenge identified by UNESCO (2017) between ESD skills measurement and ESD skills outcomes such as participation in sustainable development issues.

## 5.3 Areas of improvement

While the study succeeded in meeting its research objectives, it did not come without certain limitations. Firstly, the design of the ESD questions involved using a single reference Frijters (2016) which possessed few overlaps in the meaning of its ESD principles. This may have resulted in possible multicollinearity amongst the variables, making analyses such as regression models difficult to validate. Secondly, the assumption of MCA is that fewer dimensions are sufficient to explain most of the variance in the data, this however meant that some of the data was not captured by the dimensions. Additionally, an apriori requirement of k-means is to determine the number of clusters beforehand. While determination of these clusters is typically done through the Average Silhouette Width (ASW) method, it could still provide inaccurate clusters, sometimes even overlapping each other (Jie et al., 2020). However, in the case of this study, mostly distinct clusters were formed across student respondents, thereby largely avoiding this problem. Also, the study looked specifically only at higher order cognitive skills, but other confounding variables such as socio-economic status, personality traits and socio-emotional skills could also be contributing factors to perceived future participation in sustainable development issues. Lastly, due to a smaller sample size and self-selection effects, visualisations and clusters could be conflated and not truly reflective of trends relative to data with the entire school sample.

# Chapter 6
# Conclusion

As seen through this paper, the role of higher order cognitive skills in education has started receiving widespread attention in India. The implementation of the National Education Policy 2020 has been a positive move in shifting the focus of its education systems away from rote learning towards more hands-on and creative learning. While it is a laudable policy move, there appears to be a lack of literature on its effects on the ground. This study therefore aimed to bridge this gap by measuring higher order cognitive skills through the ESD framework and analyse it against students perceived participation in sustainable development issues. It was measured through a cross-sectional survey towards private high school students belonging to a school located in the South-Indian metropolitan city of Chennai.

Since the survey consisted of several categorical variables, the analysis technique used was an MCA k-means algorithm which comprised of dimensionality reduction with MCA and clustering with k-means. The study's data and methods were able to successfully provide clear association trends between student perceptions of ESD skills learning in schools and their perceived future participation in sustainable development problems. Since the study investigated the associations only on a specific education board, further research could explore potential education board differences – for instance, between schools belonging to State Board and CBSE education boards. Additionally, measurement of other factors such as personality traits against perceived engagement and self-efficacy towards sustainable development issues could also be a fruitful avenue to further understand its impacts on student perceptions in this context.

From an analytical methods standpoint, a combination of supervised classification techniques such as regression analysis and unsupervised classification techniques such as MCA and k-means clustering could prove useful in conducting future investigations into categorical associations such as those posed in the study. Looking deeper into factors relating to higher order skills and practical learning outcomes like perceived future participation in sustainable development issues could uncover hidden policy implications, for the benefit of future generations to come.

# Annex A

Table S1: ESD Principles and Design Criteria from Frijters (2016)

| S.no | Principles | Meaning | Examples of design criteria |
|---|---|---|---|
| 1 | Student-oriented | Accounting for students' education level, interest and attitudes towards sustainable development issues | • In line with the mental development (level) of the student.<br>• Take into account the necessary (ecological) prior knowledge.<br>• Use the student's context (field of experience).<br>• Design student assignments and provide examples that are recognisable, realistic and meaningful for students. |
| 2 | Value oriented/critical thinking | Learning how to think critically and make judgments on sustainable development issues, while reflecting on these with other students. | • Let students make (moral) judgments on the basis of society, environment and economy.<br>• Let students carry out activities in which sharing and exchanging reasoned views and reflecting on these is an essential element.<br>• Let students make their own reasoning explicit.<br>• Let students formulate solutions together. |
| 3 | Participation and collaborative learning | Students carry out practical tasks related to sustainable development independently with stakeholders inside and outside the school | • Create learning situations that give students the opportunity to be active in extracurricular contexts and to participate in real-life societal issues related to sustainable development.<br>• Let students work together with stakeholders within and outside the school. |
| 4 | Action-oriented | Students experience real participation inside and outside the classroom | • Let students link the results of their educational activities (research) to concrete action.<br>• Let students carry out the actions on their own as much as possible. |

| | | | |
|---|---|---|---|
| 5 | Complexity and coherence | Students' application of systems thinking i.e., analysing the interrelationships between environment, society and economy | • Use examples with a complexity level that students can comprehend.<br>• Work on gaining insight into the relationships that characterise environmental problems.<br>• Let students work on a concrete scenario with multiple causes and consequences, but also with multiple potential solutions. |
| 6 | Investigative attitude | Students build an inquisitive attitude through conducting their own research into a sustainable development problem | • Let students conduct action research into a problem that is recognisable, realistic, meaningful and related to sustainability.<br>• Let students go through methodical steps in their action research.<br>• Let students apply and evaluate the results of their action research.<br>• Let students reflect on the results of their research. |

Source: Authors compilation based on Frijters (2016)

# Annex B

Table S2: RMIT Measurement of Environmentally Aware and Responsible (EAR) Graduate Sustainability Attribute Across Levels

| **Level of Attribute Awareness** | **Descriptor** | **Survey Response Options to Case/Vignette Scenario** |
|---|---|---|
| Non-awareness | Does not recognize social and environmental impacts of practice/human activity | Do not consider your workplace to negatively impact the environment |
| Awareness 1 | Recognizes social and environmental impacts of practice/human activity, however does not believe change is necessary | Be aware of the impacts but do not take any action and continue with current practice |
| Awareness 2 | Recognizes social and environmental impacts of practice/human activity and sees that some level of change may be necessary, however leaves it to others to take responsibility | Be aware of the impacts and let others take responsibility for reducing impacts |
| Responsibility 1 | Recognizes social and environmental impacts of practice/human activity and takes minimum action to make changes to practice | Tell others about the impacts you have identified |
| Responsibility 2 | Recognizes social and environmental impacts of practice/human activity and takes active responsibility for taking action to reduce these impacts | Support change through actively adjusting your practice in every aspect necessary to bring about change |
| Leadership 1 | Recognizes social and environmental impacts of practice/human activity and makes changes and supports others to do the same | Make changes to your practice to reduce impacts and suggest changes to reduce impacts to other staff/employers to support wider change |
| Leadership 2 | Recognizes social and environmental impacts of practice/human activity and creates and implements change projects that influence others in community or workplace | Develop your own strategy for reducing environmental and/or social impacts of practice, and actively support others in your workplace to implement or contribute to this |

Source: Author's compilation based on Sandri, Holdsworth and Thomas (2018b, p. 419)

# Annex C

Table S3: Inertia values maintained by each dimension

| Dimension | Inertia | Cumulative Percentage |
|---|---|---|
| 1 | 0.280367 | 38.50% |
| 2 | 0.157637 | 21.65% |
| 3 | 0.108895 | 14.96% |
| 4 | 0.032786 | 4.50% |
| 5 | 0.01698 | 2.33% |
| 6 | 0.008902 | 1.22% |
| 7 | 0.008378 | 1.15% |
| 8 | 0.005894 | 0.81% |
| 9 | 0.003917 | 0.54% |
| 10 | 0.003383 | 0.46% |

# Annex D

Table S4: Summary Statistics

| Variable | Observations | Mean | Min | Max |
|---|---|---|---|---|
| **Student Characteristics** | | | | |
| Gender | 60 | .5 | 0 | 1 |
| Specialization | 60 | 1.7 | 1 | 3 |
| Duration of study | 60 | 1.7 | 1 | 4 |
| **School ESD Traits** | | | | |
| Student Oriented Q1 | 60 | 3.6 | 1 | 5 |
| Student Oriented Q2 | 60 | 3.917 | 1 | 5 |
| Systems Thinking Q1 | 60 | 3.817 | 1 | 5 |
| Systems Thinking Q2 | 60 | 3.483 | 1 | 5 |
| Critical Thinking Q1 | 60 | 3.533 | 1 | 5 |
| Critical Thinking Q2 | 60 | 3.417 | 1 | 5 |
| Critical Thinking Q3 | 60 | 3.6 | 1 | 5 |
| Participation and Collaborative Learning Q1 | 60 | 3.833 | 1 | 5 |
| Participation and Collaborative Learning Q2 | 60 | 3.4 | 1 | 5 |
| Participation and Collaborative Learning Q3 | 60 | 3.717 | 1 | 5 |
| Action Oriented Q1 | 60 | 3.617 | 1 | 5 |
| Action Oriented Q2 | 60 | 3.267 | 1 | 5 |
| **Perceived Future Participation in Sustainable Development Issues** | | | | |
| Perceived attitudes towards a development issue | 60 | 2.867 | 1 | 6 |
| Perceived engagement in future work | 60 | 4.017 | 2 | 5 |
| Perceived self-efficacy towards tackling development issues | 47 | 3.532 | 2 | 5 |
| **Other External Factors** | | | | |
| External learning platforms | 60 | 1.467 | 0 | 3 |
| Fathers influence | 47 | 2.468 | 1 | 4 |
| Mothers influence | 47 | 2.574 | 1 | 4 |
| *Personality Traits* | | | | |
| Agreeableness Q.1 | 60 | 4.117 | 1 | 5 |
| Agreeableness Q.2 | 60 | 4.017 | 1 | 5 |
| Conscientiousness Q.1 | 60 | 3.533 | 1 | 5 |
| Conscientiousness Q.2 | 60 | 3.817 | 1 | 5 |
| Openness Q.1 | 60 | 3.95 | 1 | 5 |
| Openness Q.2 | 60 | 3.883 | 1 | 5 |

Table S5: Variables Coding

| Variable Name | Variable Label | Coding |
|---|---|---|
| **1. Student Characteristics** | | |
| gender | Gender of student | 1=Male<br>0=Female |
| schoolstandard | School standard of student | 1=10th<br>2=11th<br>3=12th |
| educboard | Education board of student | State Board |
| stream | Subject specialization of student | 1=General<br>2=Science<br>3=Commerce |
| schoolduration | Duration of study in the school | 1=Since Pre-KG/UKG<br>2=Since Primary School<br>3=Since Secondary School<br>4=Since Higher Secondary School |
| **2. School Traits** | | |
| so1 | Student Oriented Q1 | 1=Strongly Disagree (SD)<br>2=Disagree (D)<br>3=Neutral (N)<br>4=Agree (A)<br>5=Strongly Agree (SA) |
| so2 | Student Oriented Q2 | |
| st1 | Systems Thinking Q1 | |
| st2 | Systems Thinking Q2 | |
| ct1 | Critical Thinking Q1 | |
| ct2 | Critical Thinking Q2 | |
| ct3 | Critical Thinking Q3 | |
| pc1 | Participation and Collaboration Q1 | |
| pc2 | Participation and Collaboration Q2 | |

| | | |
|---|---|---|
| pc3 | Participation and Collaboration Q3 | |
| ao1 | Action Oriented Q1 | |
| ao2 | Action Oriented Q2 | |
| **3. Future Participation in Sustainable Development Issues** | | |
| futurework | Hypothetical Scenario of Sustainable Development Issues in Future Workplace | 1=Do not consider your workplace to negatively impact the environment and/or society<br>2= Be aware of the impacts and let others in the workplace take responsibility for reducing them<br>3=Tell others in the workplace about the impacts you have identified<br>4=Develop strategies to actively adjust your own practice<br>5=Develop strategies for the workplace and actively support others in the workplace to contribute to them |
| selfefficacy | Perceived self-efficacy of student's own skills | 1-Not at all<br>2-Slightly<br>3-Moderately<br>4-Very<br>5-Most definitely |
| pressprob | Mapping personal attitudes towards specific sustainable development issues | 1=Environmental Degradation (eg., climate change, loss of biodiversity, excess land use)<br>2=Social Injustice/Exclusion (eg., gender inequality, poverty, human rights violations)<br>3=Economic Instability (eg., inflation, unemployment, recessions)<br>4=Unsure<br>5=Nothing really<br>6=Other: _____ |
| **4. External Factors** | | |
| fatherpressprob | Parental influence of father working on this issue | 1=Not at all<br>2-Somewhat<br>3=To a great extent<br>4=Unsure |
| motherpresspob | Parental influence of mother working on this issue | |
| extlearn | External learning sources apart from school material | 0=Fully Physical<br>1=Fully Online<br>2=Mixed |
| ***Personality Traits*** | | |
| agr1 | Agreeableness Q1 | |

| | | |
|---|---|---|
| agr2 | Agreeableness Q2 | 1=Strongly Disagree (SD)<br>2=Disagree (D)<br>3=Neutral (N)<br>4=Agree (A)<br>5=Strongly Agree (SA) |
| con1 | Conscientiousness Q1 | |
| con2 | Conscientiousness Q2 | |
| open1 | Openness Q1 | |
| open2 | Openness Q2 | |

# Annex E

Fig. S1: MCA k-means cluster map Cluster 1 – ESD Agree Choosers vs. Perceived Engagement Level(s))

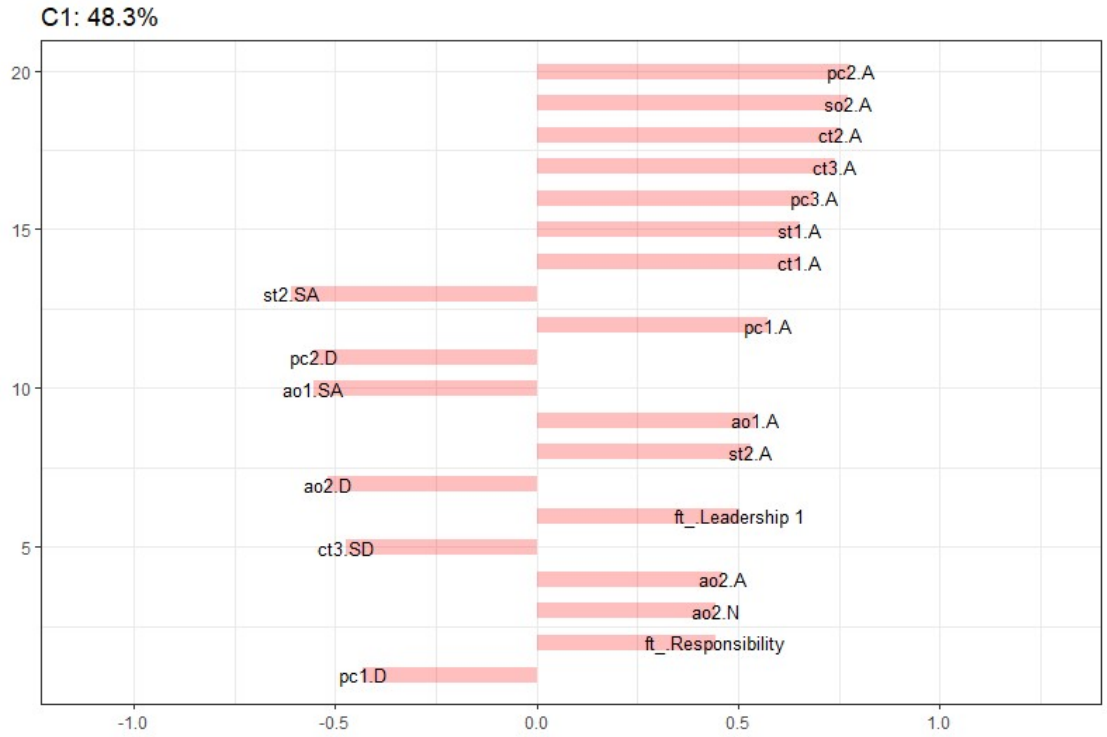



Fig. S2: MCA k-means cluster map Cluster 2 – ESD Strongly Agree Choosers vs. Perceived Engagement Level(s))

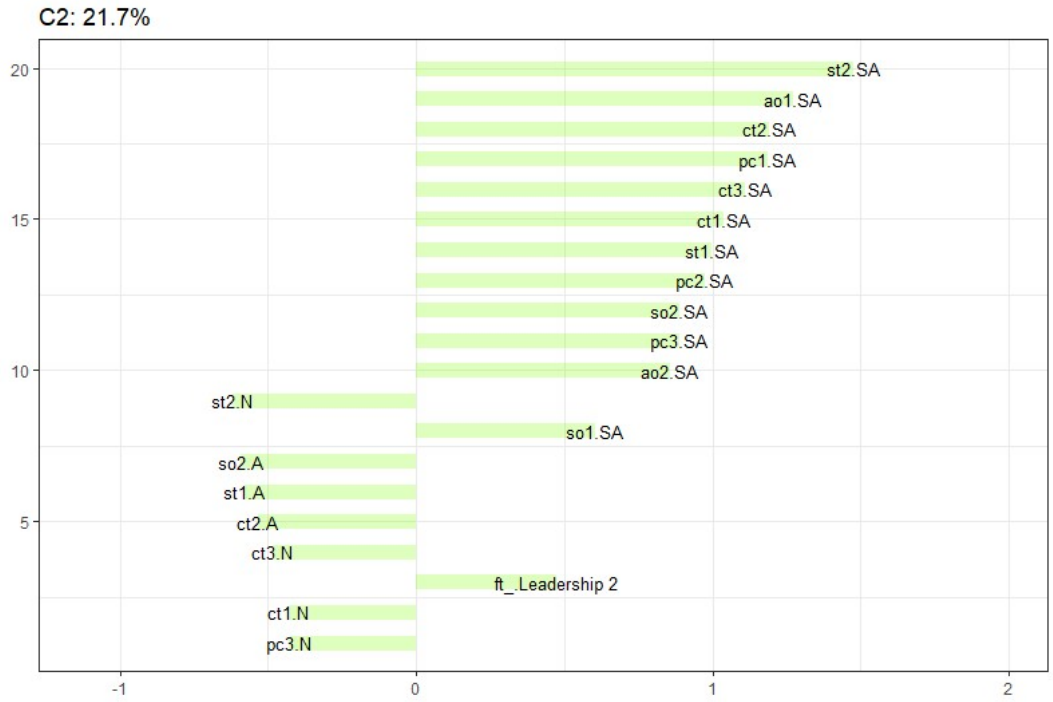


Fig. S3: MCA k-means cluster map Cluster 3 – ESD Disagree/Neutral Choosers vs. Perceived Engagement Level(s))

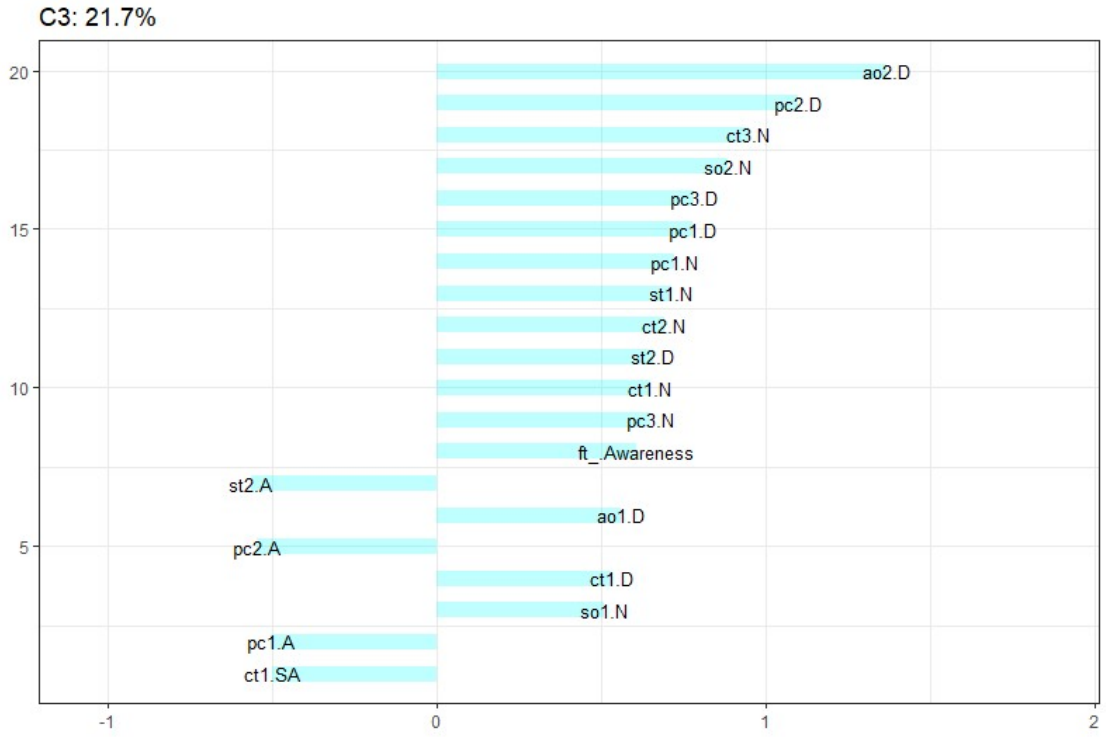



Fig. S4: MCA k-means cluster map Cluster 4 – ESD Strongly Disagree Choosers vs. Perceived Engagement Level(s))

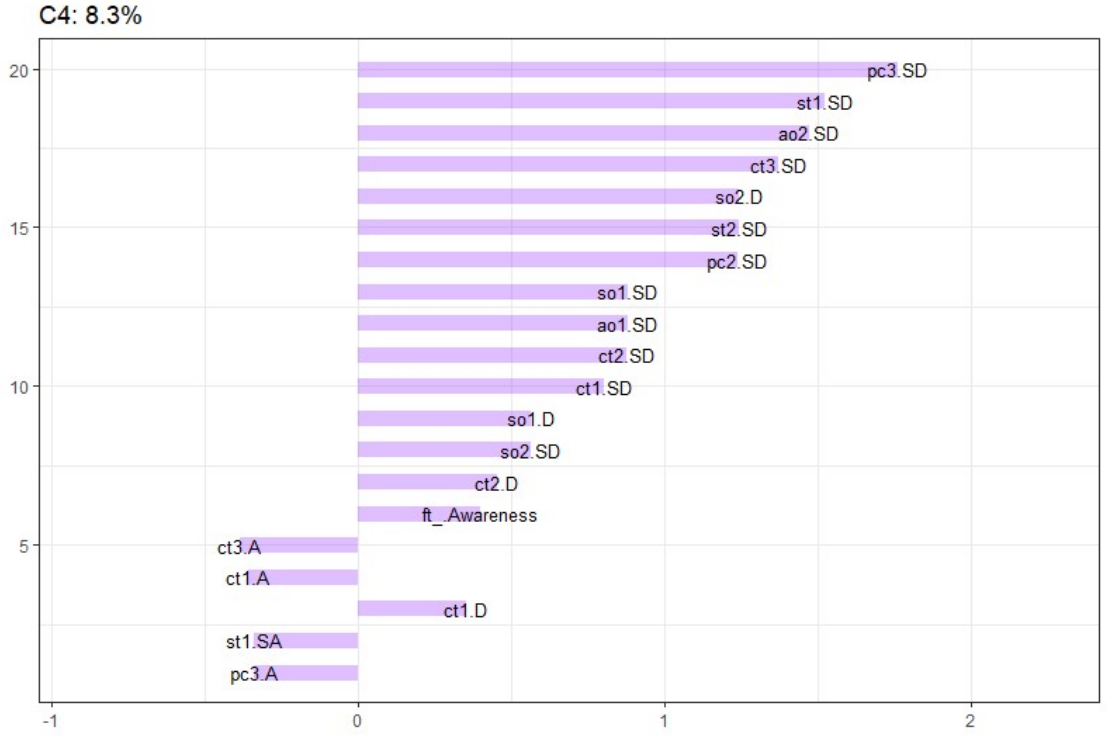
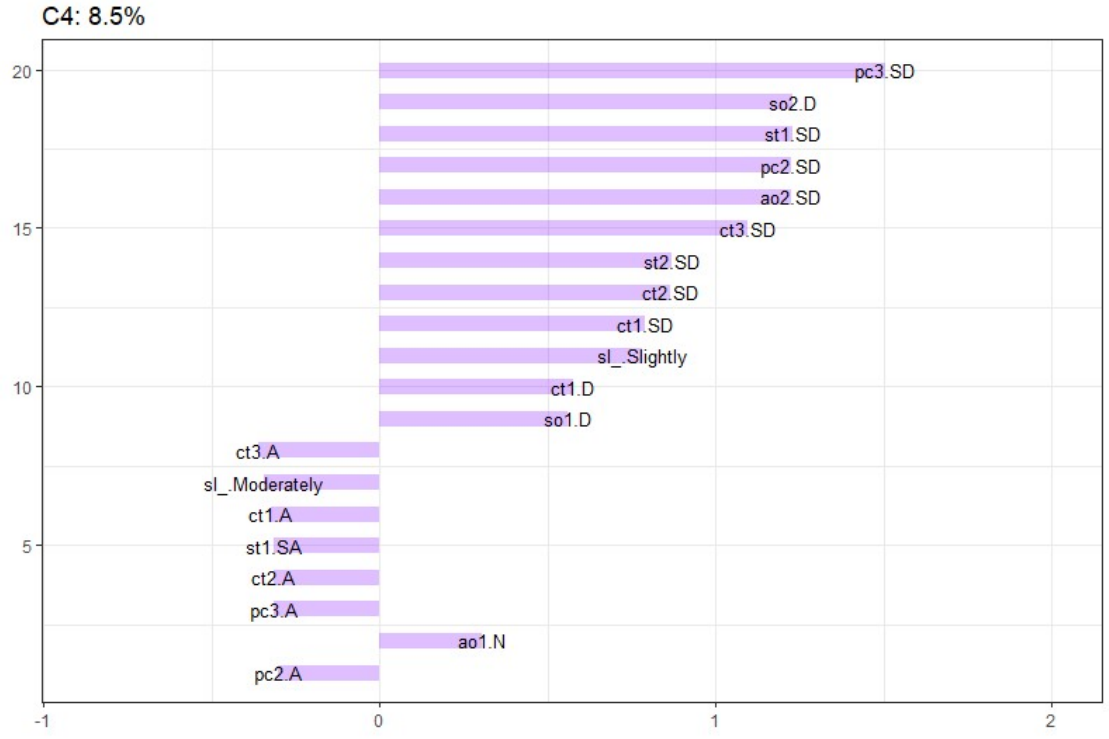


Fig. S5: MCA k-means cluster map Cluster 4 – ESD Strongly Disagree Choosers vs. Perceived Self-efficacy Level(s))



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