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Comparison of Learners' Self-Direction Behavior Across Contexts and Phases

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Abstract: This study investigates the transferability of Self-Direction behavior across different contexts and phases of learning using the GOAL system. Self-directed learning (SDL) is crucial for lifelong learning. It is significantly influenced by Self-Direction Skills (SDS), a meta-skill that is said to be transferable across different contexts, including the ability to identify learning needs, set goals, select strategies, and evaluate outcomes. Utilizing log data collected from Japanese junior high schools and analyzed using the iSAT system, we explored how Self-Direction behavior acquired in one context can be transferred to another and how these skills vary across the SDL phases. The results indicated that the Self-Direction behavior transferred between different activities and phases. In addition, the way of transfer is suggested to vary from phase and context. This study provides useful insights for the design and guidance of SDL support systems in educational programs. It suggests that it is important for educators to identify factors that facilitate the development and transfer of SDS.
Keywords: Self-directed Learning, Behavior, Across Contexts, GOAL system

1. Introduction

Soft skills, including meta-skills such as "interpersonal skills," "problem-solving skills," and "management skills" are recognized for their adaptability across various situations. (Bridges, 1993; Senova, 2020). In this sense, these skills are acquired and appear across various activities, contexts, and domains. Indeed, teachers are providing cross-contextual opportunities for learners to acquire these skills such as through Social-emotional learning (SEL), classroom activities, and school events. However, it has also been noted that these skills may vary in their function depending on personality and environment, and whether these skills are transferable across contexts is still under discussion.

Self-direction Skill (SDS) is such a meta-skill, integral to the Self-directed Learning (SDL) process, that empowers learners to independently identify their learning needs, set goals, select strategies, and evaluate outcomes (Yang et al., 2023). The Goal-oriented active learning (GOAL) system, a web-based application, was developed based on this premise to understand the complex and different contexts of learning activities and exercises, to make SDL effective, and to support planning, execution, and reflection (Majumdar et al., 2018). Previous research has demonstrated that SDS can be practiced and applied in diverse contexts and subject areas; that is, the skills are generic and transferable (Atake et al., 2024; Brandt, 2020; Budge, 2000). Specifically, the analysis of learners' SDS scores using trace data from the GOAL system suggests that the SDS acquired during a data-driven activity can be transferable across various activities (Atake et al., 2024). However, prior research has not completely addressed certain limitations, including analyses outside of a specific phase. In this sense, whether SDS skills are transferable across contexts is still under discussion.

Therefore, this study aims to clarify transferability in the five DAPER processes. A brief definition of transfer by Lobato (2012) is that “Past experiences carry over from one context to the next” (p. 232). Based on these, we set the purpose of this study to confirm whether SDS

can be carried on even if the context changes, and to investigate whether the transition varies from phase to phase by extending the SDS phases that were the limitation of the previous study. To achieve this objective, two research questions were set.

RQ1 Does learner's Self-direction behaviors transfer when the activity contexts change?
RQ2 Does the way Self-direction behaviors transfer across DAPER phases vary when the activity contexts changes?

We answer these questions with the trace data accumulated in the GOAL system. Clarifying these questions will contribute to the consistent application of SDS in diverse SDL environments and validate the claims of previous studies as evidence derived from trace data.

2. Methodology

2.1 SDL Process Model and Self-Direction Behavior Level

We used Self-direction skill scores (SDS score) collected from the GOAL system for analysis. The GOAL system adopted a generic SDL process model that is called DAPER (Data collection - Analysis - Plan - Execution Monitoring - Reflect) process model (Majumdar et al., 2019) and collects learners' activity and interaction logs on these five phases. This SDS score, ranging from 0 to 4, is computed in the system based on the activity and interaction logs across the five phases of the DAPER model, representing the weekly status of learners' self-direction skills (Majumdar et al., 2019). The computation logic of SDS is shown in Table 1 (Yang et al., 2021) and has been examined and applied in other studies（Majumdar et al., 2018）. In this study, we regard SDS as different levels of self-direction behavior.

First, In the data collection phase, learners initiate the gathering of data related to the activities for applying Self-directed Learning (SDL). This is achieved either by the synchronization step involving aggregating data from various devices, whereas the CollectionReflection step requires manually gathering and critically reflecting on one's learning data.

Next, during the Analysis phase, individuals assess the gathered data to understand their activity trends and ascertain the status of their activities. This is achieved by the evaluation step analyzing visualized self-data and group averages, and then evaluating their status as positive or negative.

Within the Planning phase, based on the analysis, individuals create SMART (Specific, Measurable, Appropriate, Relevant, and Timely) plans for activities. This is achieved by planning steps specifying daily goals, frequency, and time frame (e.g., reading 20 pages every day in July for an extensive reading goal).

As for the Execution and monitoring phase, learners conduct the Monitoring-Evaluation step so that planned actions are implemented while regularly collecting data to monitor progress, with continuous evaluation of whether the progress is delayed, on track, or ahead of schedule.

When entering the Reflection phase, learners review the execution of their plan, evaluating the plan's quality, the level of achievement, and the effort. Then, they reflect on the process, considering any current problems, strategies employed, or further actions needed.

Table 1. The level and description of Self-direction behavior

Behavior Level	Data sufficiency	Status identification	SMART planning	Regular monitoring	Strategic reflection
4	76-100%	Check data and success-fully identify status without system recommendation	Set appropriately challenging plan after analysis	Check progress and self report more than twice	Reflect by self-rating and further comments

3	51-75%	Check data and success-fully identify status with system recommendation	Set too difficult plan after analysis	Check progress and self report twice	Reflect by self-rating but did not write comments
2	26-50%	Check data but partially identify status	Set too easy plan after analysis	Check progress and self report once	Reflect on personal plan and achievement
1	1-25%	Check data but did not identify status	Set plan without analysis	Check progress but did not self-report	Reflect on personal plan only
0	No data collected	Never analyze	Never plan	Never monitor	Never reflect

2.2 Data and Analysis Method

In this study, data from Japanese junior high schools collected from June 2020 to March 2023 were used. In this period, a total of 39,765 records were collected from a cohort of 120 learners. However, not all 120 learners participated in all activities, and some deficiencies were observed. Therefore, learners who did not participate in even one activity were excluded from the study. Therefore, data from 116 learners were finally analyzed. Within the GOAL system, Self-directed learning (SDL) took place across diverse activities and domains, including Extensive Reading, Mathematics, Steps taken, and Sleep. The activities of Extensive Reading and Mathematics contexts are partly supported by teachers where learners did not determine fully their SDL activities. (e.g., the teacher introduces the activity and instructs how to conduct it). Conversely, the domains of Steps taken, and Sleep were entirely learner-centered activities; teachers' roles were limited to the provision of wearable devices, leaving the learners to independently manage their activities. In this study, the highest SDS score within the period under analysis was considered as learners' self-direction behavior.

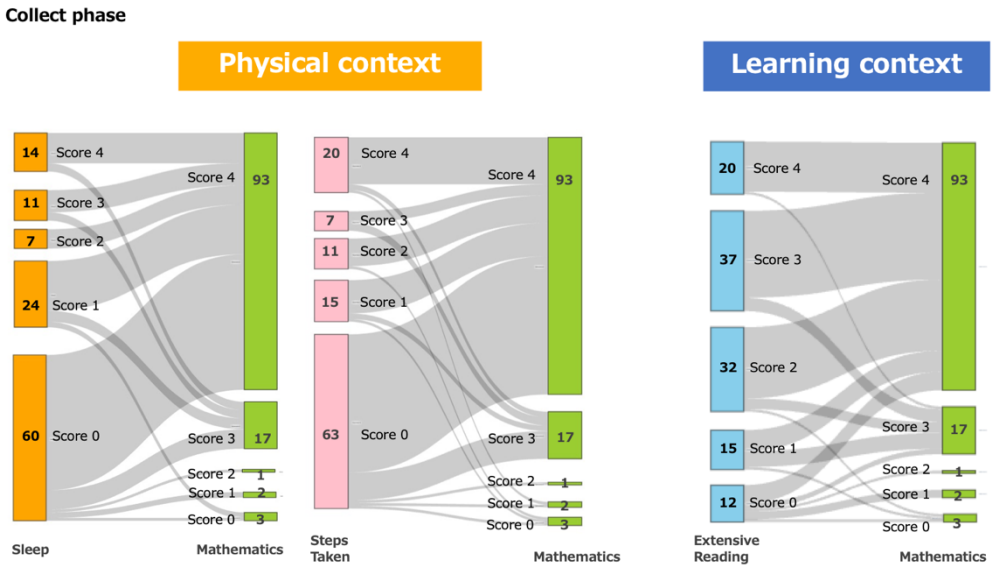
To answer these research questions, we used iSAT (Majumdar et al., 2016) to analyze transition patterns across the self-direction behavior levels (strata in the iSAT diagram) across the activity contexts. Our distinct activity contexts were considered as phases in the iSAT diagram: Sleep, Steps Taken, Extensive Reading, and Mathematics. The self-direction behavior level is considered as a strata in the iSAT diagram and indicates the count of individuals attaining that behavior level in a particular activity. In our dataset, the mathematics was intensively conducted in the latter half of the period, hence that is positioned to the right, indicating a subsequent activity. On the other hand, Sleep, Steps Taken, and Extensive Reading were aligned to the left, signifying prior activities. The transitions within the iSAT diagram depict the migration of scores from one context to another. iSAT analysis helps to describe the transition patterns and we can confirm to what extent the learners transfer the self-direction behavior when the context changes. Patterns such as Aligned (remaining the same in the DAPER phase across different contexts), Starburst (the behavior improves from the prior context to the subsequent context), and Slide (the behavior downgrades from the prior context to the subsequent context). Based on this, we answered RQ1. Each visualization provides an overview of transitions across the behavior levels. The proportion of each pattern (Remain, Starburst, Slide) as calculated by the number of learners who maintained, improved, or downgraded, are further tabulated.

To answer RQ2, we tabulated the maximum transition across each of the context which does not remain such as score 0 to 0 (no observed behavior in both the context). This highlights which behavior level is mostly maintained across the activity context. Finally, the results for each phase are summarized in Table 2.

3. Result

3.1 Data collection phase

The results of the iSAT diagram show more improvement than maintenance across all contexts in the data collection phase (Figure 3). Whether due to sleep, steps taken, or reading more, there is a trend toward improvement (approximately 80%) in math activities. Remains are generally between 10% and 20%, and downgrades are less than 5%. This result suggests that the score improves in the posterior activity during the data collection phase. Additionally, there are very few learners whose scores drop to 0. Therefore, it is suggested that a transfer of Self-direction behavior is occurring in the Data collection phase.



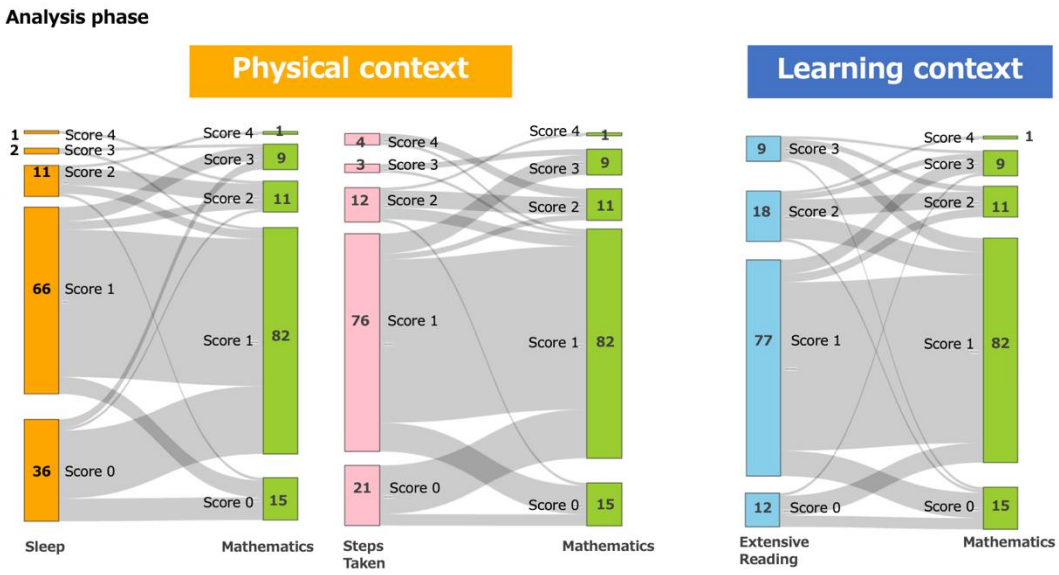
(a) Remain*	**15 (12.9%)**	**21 (18.1%)**	**24 (20.7%)**
(b) Improve*	**96 (82.8%)**	**90 (77.6%)**	**89 (76.7%)**
(c) Downgrade*	**5 (4.3%)**	**5 (4.3%)**	**3 (2.6%)**

*The Number and Ratio(%) of learners who remain in the same score level (a) , who improve (b) and downgrade(c).

Figure 1. iSAT analysis of the transition of Collection behavior levels across contexts.

3.2 Analysis phase

The analysis phase has already been analyzed in a previous study by Atake et al. (2024). However, due to differences in the way the missing sites were handled, the visualization was performed again in this study and the results were added. In the analysis phase, most learners maintain their SDS scores across different contexts. The ISAT diagram (Figure 4) shows that about 60% of the learners maintain the same score in all contexts. On the other hand, approximately 20% to 30% of the learners improve their scores, while approximately 10% to 20% of the learners decrease their scores. Whether improvement or decline is more common depends on the activity, and the trend is not consistent. In addition, there are few learners whose scores are shifting to 0. Therefore, a transfer of Self-direction behavior is occurring in this phase.

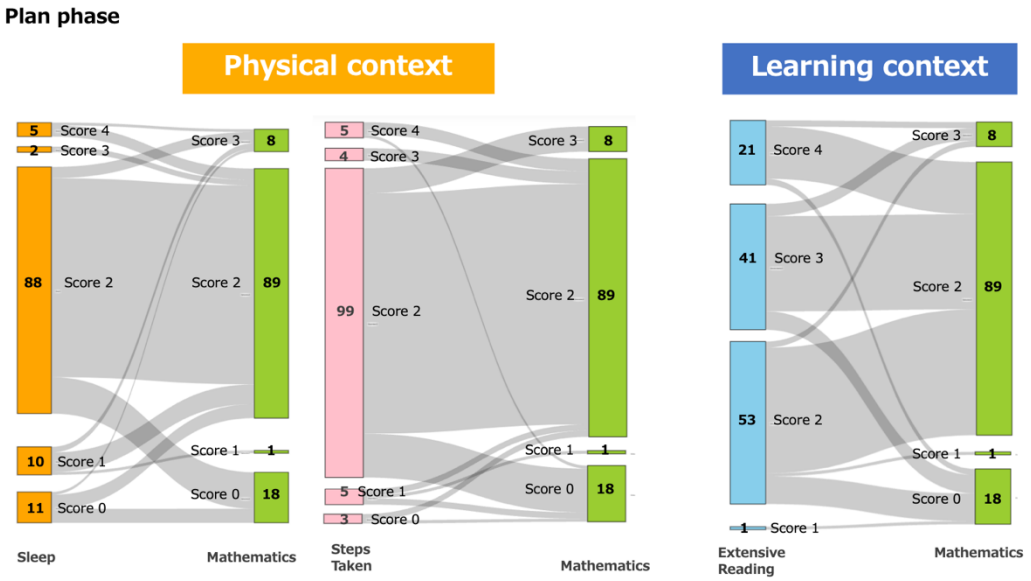


(a) Remain*	**67(57.6%)**	**69 (59.5%)**	**71 (61%)**
(b) Improve*	**37 (31.9%)**	**27 (23.3%)**	**19 (16%)**
(c) Downgrade*	**12 (10.3%)**	**20 (17.2%)**	**26 (22.4%)**

*The Number and Ratio(%) of learners who remain in the same score level (a) , who improve (b) and downgrade(c).

Figure 2. iSAT analysis of the transition of Analysis behavior levels across contexts.

3.3 Plan phase.



(a) Remain*	**77 (66.3%)**	**79 (68.1%)**	**35 (30.2%)**
(b) Improve*	**19 (16.4%)**	**12 (10.3%)**	**47 (40.5%)**
(c) Downgrade*	**20 (17.2%)**	**25 (21.6%)**	**34 (29.3%)**

*The Number and Ratio(%) of learners who remain in the same score level (a) , who improve (b) and downgrade(c).

Figure 3. iSAT analysis of the transition of Planning behavior levels across contexts.

According to the ISAT diagram visualization, the results in the plan phase differ depending on the context (Figure 5). First, in both physical contexts, approximately 70% of learners maintained their SDS score. The second most common context was Downgrade, where about 20% of the learners lost their score, followed by Improve, where 16.4% of the learners lost their score for Sleep and 10.3% for Steps taken. On the other hand, the results were different

in the Learning context. The most common was Improve at 40.5% of all learners. The next most common was Remain at 30.2%, and Downgrade at 29.3%, almost the same percentage.

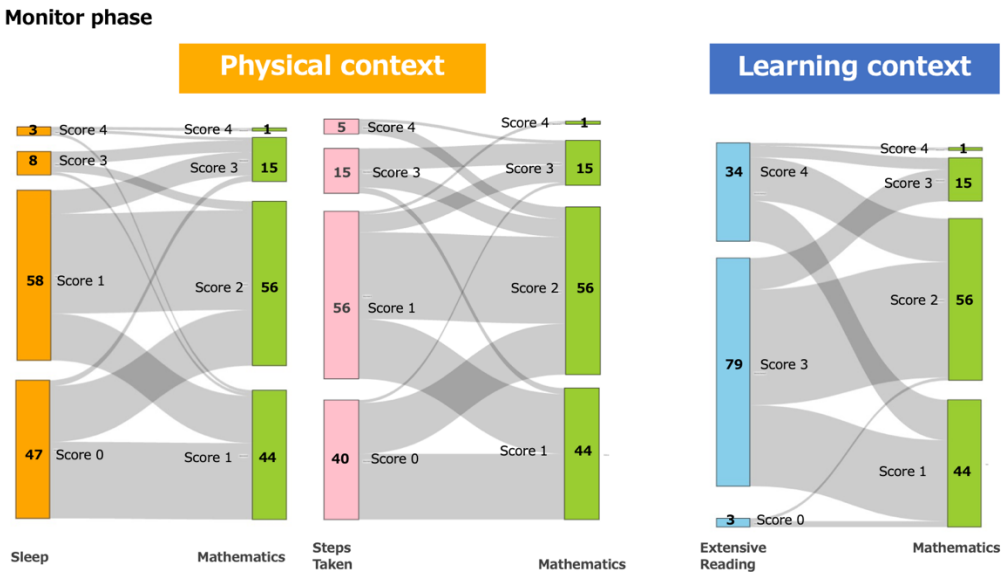
This indicates that in the Plan phase, Self-direction behavior is more likely to be maintained in the Physical context and less likely to be maintained in the Learning context. In addition, the ratio of scores shifting to 0 in all contexts is small. Thus, a transfer of self-direction behavior is also occurring in the Plan phase.

3.4 Execution Monitoring Phase

The visualization of the iSAT diagram shows that even in the monitoring phase, the results differ depending on the context (Figure 6). First, in both physical contexts, approximately half of the learners maintain their SDS score. The next most common were Improve for Sleep and Downgrade for Steps taken, at 25.0% and 28.5%, respectively. Roughly 20% of learners lost scores, with Improve at 16.4% for Sleep and 10.3% for Steps taken.

On the other hand, Downgrade was the most common learning context, with about half of the learners dropping scores. Remain was next at 39.7%, followed by Improve at 11.2%.

This indicates that Self-direction behavior in the Monitoring phase, as in the Plan phase, is more likely to be maintained in the Physical context and less likely to be maintained in the Learning context. Moreover, there are no learners who see their scores fall to 0. Based on this, it is indicated that self-direction behavior is being transferred totally during the Monitoring phase.



(a) Remain*	**65 (56.0%)**	**58 (50.0%)**	**46 (39.7%)**
(b) Improve*	**29 (25.0%)**	**25 (21.6%)**	**13 (11.2%)**
(c) Downgrade*	**22 (19.0%)**	**33 (28.5%)**	**57 (49.1%)**

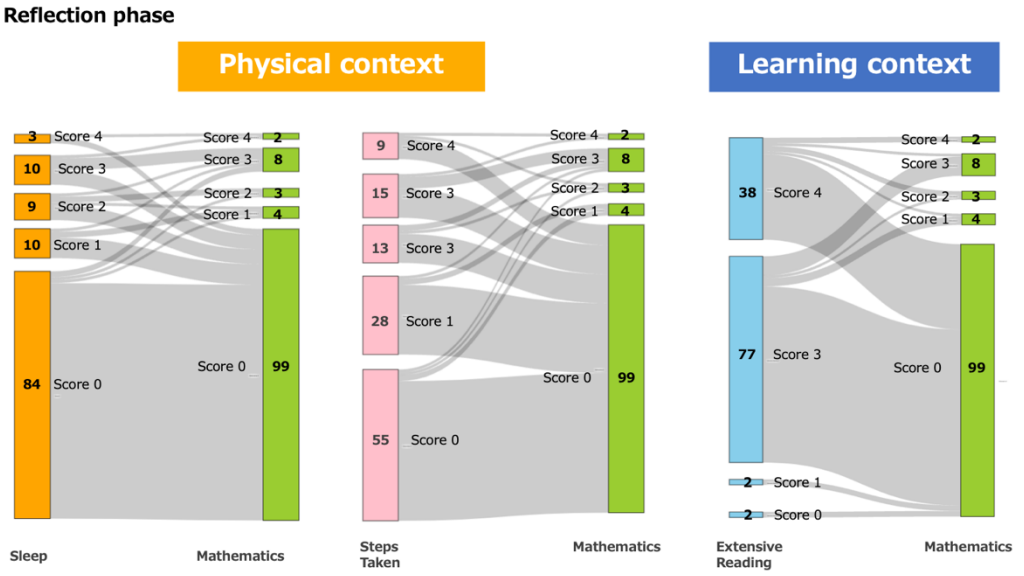
*The Number and Ratio(%) of learners who remain in the same score level (a) , who improve (b) and downgrade(c).

Figure 4. iSAT diagram of skill transfer in the Monitoring phase

3.5 Reflection Phase

Finally, the Reflection phase is discussed. In this phase, too, a high percentage of SDS scores shifted in the Physical context: 76.7% were Remain for Sleep to Mathematics; for Steps taken, 48.3% were Remain and 44.8% were Downgrade; for Steps taken, 48.3% were Remain and 44.8% were Downgrade; for Steps taken, 48.3% were Remain and 44.8% were Downgrade. On the other hand, in the Learning context, nearly 90% of the learners lost scores, with only about 3% of the learners being Remain.

It should be noted that most learners in this phase scored 0, especially in mathematics. Since a score of 0 indicates the behavior of not taking any action, it is somewhat difficult to interpret whether transfer is occurring in this phase. However, when confirming the nodes and flows, although few learners transit from 0 to 0, learners who scored 3 in the first activity, for example, often score 3 or thereabouts in mathematics as well. These facts indicate that transfer may be occurring among learners who are constantly doing their activities in the Reflection phase as well.



(a) Remain*	**89 (76.7%)**	**56 (48.3%)**	**4 (3.5%)**
(b) Improve*	**7 (6.0%)**	**8 (6.9%)**	**9 (7.8%)**
(c) Downgrade*	**20 (17.2%)**	**52 (44.8%)**	**103 (88.8%)**

*The Number and Ratio(%) of learners who remain in the same score level (a) , who improve (b) and downgrade(c).

Figure 5. ISAT diagram of skill transfer in the Reflection phase

3.6 Research Question and Its Result

We review the answers to our research questions.

(RQ1) Does learner's Self-direction behaviors transfer when the activity contexts change?

Results suggest the possibility of transfer in all contexts. To answer this research question, we first visualized each phase and context using the iSAT diagram to show the transfer of scores. If a node in the diagram does not shift to 0 in the posterior activity, we consider the self-directed behavior to be transferred. The Reflection phase was difficult to interpret because many learners scored 0 in later activity, but the results suggest that it transfers among learners who are engaged in the activity. These results indicate that self-directed behavior transfers when the context changes.

(RQ2) Does the way Self-direction behaviors transfer across DAPER phases vary when the activity contexts change?

To answer this question, we tabulated the maximum transition across each of the contexts that remain and summarized in Table 2. This table shows the level at which remain dominated the highest percentage in each activity, the number of people at that level, and the percentage of the total number of people at that level. Based on Table 2, we compared the levels with the most transitions in each phase and activity context, as well as the number and percentage of transitions. The results indicate that the transfer of self-directed behavior varies by context and phase. For example, in the collect phase, level 4 was the most likely to transfer to the same level in all activity contexts. The table shows that of the 11 learners at level 4,

9.5% of the total learners remained at the same level (in this case level 4) in the mathematics learning activity context. From this table, the activity context with the highest percentage of transitions differs for each phase and context. Therefore, these results indicate that the way of transfer of self-directed behavior varies by context and phase.

Table 2 The predominant behavior level in each Phase that remains across the Activity context. (N=116)

	Transitions from Physical contexts		Transition within Learning contexts
Phase	Sleep	Steps taken	Extensive Reading
Collect	Level 4 (n=11, 9.5%)	Level 4 (n=17, 14.6%)	Level 4 (n=19, 16.3%)
Analysis	Level 1 (n=52, 44.8%)	Level 1 (n=57, 49.1%)	Level 3 (n=53, 51.7%)
Plan	Level 2 (n=71, 61.2%)	Level 2 (n=77, 66.3%)	Level 2 (n=41,35.3%)
Monitoring	Level 1 (n=34, 29.3%)	Level 1 (n=29, 25.0%)	Level 0 (n=2, 1.7%)
Reflection	Level 0 (n=80, 69.0%)	Level 0 (n=55, 41.4%)	Level 0 (n=2, 1.7%)

4. Discussion

There are two points of contention. The first is about the possibility of ease of score maintain depending on phase and context.

In the collection phase, few learners maintained their scores. On the other hand, in the analysis phase, most learners maintained it in all contexts, and in the Plan, Monitoring, and Reflection phases, maintenance was observed only in physical contexts. This may be related to teacher-supported activities, which included teacher support for Extensive Reading and Mathematics. Indeed, during the data analysis phase, the June 2020 data showed evidence that data were artificially collected only on a few specific dates. As a result, math scores were calculated higher in the Collect phase, which is evident from the results of the iSAT diagram (80% of learners received a score of 4). A more detailed discussion of maintain in the Collect phase could be made if the data from this activity were isolated and analyzed, and it is possible that very different results could be seen in other phases as well.

The second is about the possibility of intervention by teachers. We found that in some phases the maintaining of scores from physical activities such as “sleep” and “steps” to learning activities is likely to occur, but the maintenance from learning context to learning context is less likely to occur. This may be due to the possibility that for meta-skills such as SDS skills, the physical context may be easier to transfer than the learning context. This also indicates the possibility of extending SDL activities by the teacher. For example, if acquired SDL behaviors are more transferable from the physical context than from the learning context, this suggests the possibility of smoothing SDL in learning activities by setting up new SDL activities that involve physical activities. Intervention potential in the learning context is also indicated: not only is transfer less likely to occur in the Plan, Monitoring, and Reflection phases, but the scores themselves tend to decrease. This suggests that engagement may decrease in the later stages of SDL activities in the learning context. This suggests the need for teachers to intervene in the latter half of the cycle to increase engagement.

5. Conclusion and Future Works

This study investigated to conduct an extensive analysis of the transferability of Self-direction behavior across contexts and various SDL phases using trace data from the GOAL system. The results showed that there is a certain degree of transferability in how SDS scores transfer among different activities and phases. The patterns of these associations are varied. In particular, in the context of physical activity, such as Sleep" and Steps taken, showed more consistent maintenance, especially in the Plan, Monitor, and Reflect phases. This suggests that Self-direction behavior developed in the context of managing Physical context has broader implications and is transferable to academic pursuits. On the other hand, the transferability of the Self-direction behavior in Extensive Reading was more limited, suggesting transferability only primarily in the "collecting" and "analyzing" phases.

The results also highlight the complex dynamics between different learning contexts and the way of transfer of SDS. We observed that the maintenance of SDS from one learning context to another was less pronounced than the transfer from the physical activity context to the learning context. This may suggest that the unique challenges and nature of learning activities or how self-determination is facilitated and applied in such environments may differ.

These insights contribute to a deeper understanding of the nuances of SDS transferability and provide evidence to help design a more effective SDL support system and guidance and counseling in educational programs. By clarifying what factors influence SDS development and transfer, educators can better promote these skills in learners and ultimately support them on their path to lifelong learning.

For future work, it is essential to delve deeper into the factors that facilitate or hinder the transfer of SDS. For example, learners' motivation and interest in the subject matter could have affected the transferability of this study. Further investigation of these factors could help us suggest specific strategies to more effectively support the development of self-directed learning skills.

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