Differences of self-regulated learning between higher education students with and without a history of pedagogical support

A Learning Analytics Approach

Kalle Venäläinen
kao.venalainen@gmail.com

School of educational sciences and psychology, UEF[1], Joensuu, Finland

Erkko Sointu
erkko.sointu@uef.fi

School of educational sciences and psychology, UEF, Joensuu, Finland

Sanna Väisänen
sanna.m.vaisanen@uef.fi

School of educational sciences and psychology, UEF, Joensuu, Finland

Sonsoles López Pernas
sonsoles.lopez@uef.fi

School of Applied Educational Science and Teacher Education, UEF, Joensuu, Finland
School of Computing, UEF, Joensuu, Finland

Ville Tuominen
ville.m.tuominen@gmail.com

Valamis, Joensuu, Finland

Teemu Valtonen
teemu.valtonen@uef.fi

School of Applied Educational Science and Teacher Education, UEF, Joensuu, Finland

Mohammed Saqr
mohammed.saqr@uef.fi

School of Computing, UEF, Joensuu, Finland

Jyrki Virtanen
jyrki.virtanen@uef.fi

Institute of Public Health and Clinical Nutrition, UEF, Joensuu, Finland

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[1] University of Eastern Finland

Laura Hirsto
laura.hirsto@uef.fi

School of Applied Educational Science and Teacher Education, UEF, Joensuu, Finland

Abstract

Despite the growing awareness of students' needs for support in higher education, research in this area is still lacking. Here, we investigated the self-regulated learning of students in Finnish higher education – those with and without a history of pedagogical support from their previous school levels – in flipped courses using both dispositional learning analytics and learning analytics data. Specifically, self-regulated learning was investigated before and after course participation across the entire sample (N=217), and possible differences were compared within a limited subset of participants (N=108). We found that self-regulation of process and results, lack of regulation and shared regulation increased, while task avoidance decreased, for all students between two measurement points. When comparing the groups using dispositional learning analytics, students with a history of pedagogical support (N=38) had more positive experiences with the learning management system than the group without a history of pedagogical support (N=179). Interestingly, more differences between groups with and without a history of pedagogical support were found using learning analytics data.

Keywords: e-learning; higher education; self-regulated learning; learning analytics; dispositional learning analytics; flipped learning; flipped classroom

Introduction

As the number of higher education (HE) students increases worldwide (Marginson 2016) and in Finland (Official Statistics of Finland 2021a, 2021b), ways to support students' learning with accuracy and appropriateness should be considered paramount. Around 6-12 % of Finnish university students experiences learning challenges (Korkeamäki & Vuorento 2021; Rinne et al. 2021), and 14.1 % have received support for learning (e.g. pedagogical support) in previous school levels (Kiljunen et al. 2023). While support for learning can be multidisciplinary and should vary in form depending on the learner (e.g. Finnish National Agency for Education 2014), pedagogical support refers to pedagogy (i.e., how education should be organized) and support (i.e. how pedagogy is organized to support learning based on the various needs of students or student groups; Sointu et al. 2024b). As declared by the UN (1948), HE should be available for everyone. Furthermore, the UNESCO Salamanca statement (1994) asserted the need for educational systems to implement inclusive practices. In Finland, pedagogical support in basic education is governed by law and national core curriculum, and support is based on individual needs of a student or group of students

based on inclusive practices (for more information particularly in learning analytics perspective, see Sointu et al. 2024a). However, pedagogical support in HE is not always available, or it is provided in ways that does not promote learning for everyone (Pesonen & Nieminen 2021; Sointu et al. 2024b). Nonetheless, students in HE should be supported for equity without decreasing the expectations for learning outcomes (cf. Non-discrimination Act 1325/2014) and offer reasonable accommodations to enable learning. Moriña (2017) noted that the right to participate in education does not render inclusion by itself, as teaching practises and institutional policies are central to inclusive participation. One way to enhance our understanding of inclusive learning is through self-regulated learning (SRL) research (Ness & Middleton 2012).

SRL is considered multidimensional (e.g. Panadero 2017) and previous studies have shown that it is linked to student performance in HE (e.g. Lai & Hwang 2016; Hyppönen et al. 2019). Moreover, there seems to be a consensus that SRL is a learnable skill (e.g. Boekaerts 1997; Zimmerman 2000; Usher & Schunk 2018), and some preliminary evidence indicates that pedagogical approaches such as flipped classroom and flipped learning might lead to increased SRL skills among students (e.g. Lai & Hwang 2016). Within a systematic review of SRL and learning analytics (LA), Hirsto and colleagues (2022) concluded that while learning analytics is being used to measure and support elements of students' SRL, there is room for improvement. Similarly, Sønderlund and colleagues (2018) found that, despite the need for more study, learning analytics could potentially identify students at risk, inform faculty and serve as a mean of intervention. However, knowledge of SRL among HE students with or without a pedagogical support history is still scarce. Therefore, our aim was to investigate SRL with dispositional learning analytics (i.e. questionnaire) data and learning analytics data among HE students with and without a history of pedagogical support in previous school levels.

Elements of self-regulated learning

There are numerous theories about the function and form of SRL (e.g. Panadero 2017), to include its cognitive, metacognitive, behavioural, motivational and affective elements (e.g. Boekaerts 1997; Zimmerman 2000; Panadero 2017). According to Pintrich (2000), SRL is an active process of goal setting through which cognitive, behavioural and motivational control is attempted within environmental and contextual constrictions. SRL is predominantly described as a cyclical process consisting of actions towards internally or externally set goals and the use of feedback to review progress in this regard (e.g. Pintrich 2000; Zimmerman & Moylan 2009; Zimmerman & Schunk 2011; Panadero 2017).

This study uses Zimmerman's (2000) cyclical phases model (see also Zimmerman & Moylan 2009), as it is widely known and used within the context of educational psychology, and apparently serves as a basis for other SRL models and includes a solid empirical evidence base (e.g. Panadero 2017). The cyclical model includes three phases (i.e. forethought, performance and self-reflection; Zimmerman 2000) and subprocess (i.e. behavioural, environmental and covert) regulation vis-à-vis exerted effort (Zimmerman 1989). Notably, SRL is primarily considered fluctuant, as it can be affected by multiple components such as teaching (e.g. Vermunt & Vermentten 2004; Theobald 2021), social interactions (Zimmerman 1989), environmental factors (e.g. Usher & Schunk 2018) or personal experiences of self-recognised outcomes (Zimmerman & Moylan 2009). SRL processes can also be shared as a

group in form of shared regulation e.g. setting concerted goals and strategies, co-regulating motivation and emotion as well as exerting group effort toward shared activity (Panadero & Järvelä 2015).

Previous research identified SRL's importance in HE, particularly in terms of its effect on student performance (e.g. Lai & Hwang 2016; Theobald 2021) and the evident disparity between HE students' SRL skills (e.g. Virtanen & Nevgi 2010). Additionally, individual limitations (i.e. learning disabilities, lack of motivation, challenges in mental health; Zimmerman 2000) and teaching approaches (cf. Vermunt & Vermentten 2004; Theobald 2021) could negatively affect the ability to implement SRL processes, which can be particularly challenging for students who have support needs or difficulties with SRL. In response, flipped approaches (Lai & Hwang 2016; Sointu et al. 2023a) and learning analytics (Heikkinen et al. 2022) have been suggested as ways to support the learning of various students.

Flipped classroom and learning analytics

Flipped classroom and flipped learning represent a pedagogical change in teaching, where the goal is to move from a more teacher-driven education to one that is learner based (Figure 1). As flipped classroom largely embraces elements of a teaching method, flipped learning should be considered more of a learning-centred pedagogical approach (Toivola et al. 2017; Sointu 2021). According to O'Flaherty and Phillips (2015), pedagogical consistency in the implementation of flipped classroom seems lacking (i.e. no single model seems to exist). This may lead to different experiences in the learning environment, as pedagogical solutions are usually teacher based and thus prone to individual variation.
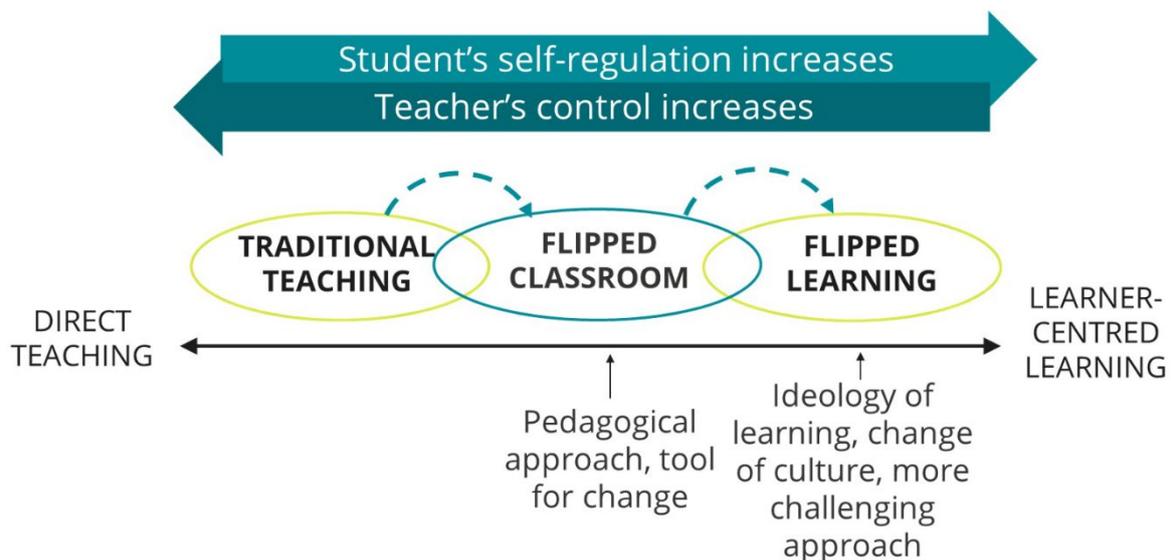

Figure 1. Traditional classroom, flipped classroom and flipped learning according to Sointu and colleagues (2023a) (adapted from Toivola & Silfverberg 2015).

As a prerequisite for participating in flipped classroom, SRL skills – to a certain degree – are needed (Lai & Hwang 2016), and a failure to adapt in the learning environment could lead to less-than-ideal learning outcomes (Chen et al. 2014). Also, not all students prefer the elements of flipped classroom or learning (e.g. Sointu et al. 2019) which may be due to

challenges of SRL. For example, time spent on pre-class activities seems to be negatively reflected in student dispositions (e.g. Hao 2016) and students with learning support seems to have lower self-regulation in flipped classroom context (Kiljunen et al. 2023). Nevertheless, a few generalisations of positive effects and affinities can be identified in flipped classroom studies, including pedagogical elements (e.g. pace of studying and flexibility; O'Flaherty & Philips 2015), methods (e.g. videos; Nouri 2016) and learning effects (e.g. higher level of learning – Gilboy et al. 2015; increases in subscales of SRL – Lai & Hwang 2016). Given flipped environment variability, SRL-supported environments – or environments that enable SRL skill use – are suggested in the literature to be more likely to aid the development of said skills (e.g. Hao 2016; Lai & Hwang 2016).

To study flipped learning and flipped classroom environments – and especially the effect they have on students – accurate details of dispositions and behavioural data are needed. According to the First International Conference on Learning Analytics and Knowledge (LAK11) learning analytics is defined as "measurement, collection, analysis and reporting of data about learners and their contexts, for the purposes of understanding and optimizing learning and the environments in which it occurs" (Siemens & Long 2011). In comparison, dispositional learning analytics (e.g. online questionnaires) is used to provide information on dispositions – for example, motivations, emotions, values or orientations (Buckingham & Crick 2012; Tempelaar et al. 2018; Sointu et al. 2023a). Learning analytics data is used for research and can also offer targeted feedback to teachers, students and administrators (Joksimovic et al. 2019). While more research is needed on learning analytics-based interventions (Sønderlund et al. 2018), examples exist of the successful implementation of learning analytics-based feedback support for increasing students` academic self-efficacy (e.g. Yilmaz 2022), learning experience (e.g. Wang & Han 2021) and perceptions on receiving feedback (Lim et al. 2021).

The scale and multidimensionality of SRL (e.g. Panadero 2017), the interconnected nature of flipped learning and SRL (e.g. Lai & Hwang 2016) and the lack of research on the differences between students with and without pedagogical support make it important to collect multiple types of information. As learning analytics is used to extract information on activities (Siemens & Long 2011), dispositional learning analytics is used to gather specific student dispositions (e.g. Buckingham & Crick 2012) – in this case, subscales of SRL.

Pedagogical support in the context of this study

In Finland, pedagogical support system (i.e. how support is provided in school by different teachers and school-related experts on a needs basis; see e.g. Sointu et al. 2024a) at the pre-HE level exists. However, pedagogical support is more vague in HE (cf. Pesonen & Nieminen 2021; Sointu et al. 2024b). Nevertheless, students in HE may have a background of pedagogical support in previous school levels (i.e. basic education, secondary education including upper secondary education or vocational education; Sointu et al. 2023), and this influences on the learning in HE. According to Kiljunen and colleagues (2023), approaches such as flipped classroom and learning can be considered as way for pedagogical support in HE. However, there are certain factors that should be taken into account in flipped teaching and that explain the satisfaction of all students in flipped approaches: guidance for selected pedagogical approach (e.g. how to study); perception aimed at understanding (i.e. combining the theoretical and practical knowledge); safe learning environment; students' technological

skills and teachers pedagogical skills (Sointu et al. 2023b). According to Kiljunen and colleagues (2023), no differences in academic performance between supported or not supported HE students exists, but supported HE students have lower self-regulation and self-efficacy, find flipped approaches more challenging, but value collaborative learning practices in flipped context. Thus, further information with dispositional learning analytics and learning analytics data are needed to understand better the role of SRL in flipped approaches.

Thus, the aim of this paper was to investigate SRL with dispositional learning analytics and learning analytics data among HE students with and without a history of pedagogical support in previous school levels. More precisely, the research questions were: (1) Is there a significant difference between the first and the last measurement point in dispositional learning analytics data among all students; (2) does differences between students with history of pedagogical support and those without support exist in the last measurement point of dispositional learning analytics data; and (3) does learning analytics data show differences of self-regulated learning between students with and without history of pedagogical support?

Methods

Participants and procedures

The convenience sample used in this study consisted of 217 higher education (HE) students, of which 92.6 % (N=201) were female and 7.4 % (N=16), male. Age varied from 20 to 60 years (M_{age}=32.9, SD_{age}=10.13). Data were collected during the academic school year 2021–2022 from two courses – educational science (N=50) and nutrition science (N=167) – at the University of Eastern Finland. Courses were chosen for two reasons. First, both courses offered similar learning environments and pedagogical planning based on the flipped approaches. Second, both courses offered combinable information that were applicable for this study. Thus, the questionnaire (i.e. dispositional learning analytics) and online trace log data (i.e. learning analytics) related to SRL were collected in the learning management system (LMS) of both courses.

The use of online trace log data was limited to participants with consent to collect and merge aforementioned data sets (N=108). Thus, we followed the Institutional Review Board (IRB) guidelines, and this explains the difference between the two data sets, and are considered as a limitation of the study. History of pedagogical support in previous educational levels information was collected via the questionnaire. From the questionnaire data, 38 (17.5%) reported that they either had received pedagogical support or had a learning-related pedagogical support statement prior to entering HE. This proportion is slightly larger than in previous studies (e.g. Kiljunen et al. 2023). Participation was voluntary; non-participation had no effect on final grade or course completion. The research design was approved by the University of Eastern Finland Institutional Review Board (decision 11/2020). The EU General Data Protection Regulation (GDPR 2016/679), Finnish National Data Protection Act (1050/2018) and ethical guidelines of research with human participants set by the Finnish National Board on Research Integrity (TENK; Kohonen et al. 2019) were strictly followed.

Course design

Courses included in this study implemented flipped approaches as the basis of a fully online learning environment design. An browser based online learning management system (LMS) was used to offer learning content to students and included videos, handouts and designated tasks. LMS offered materials and information in sections to keep information flow manageable. The use of LMS also enabled students to use the offered materials when and how they saw fit. However, students were guided to use the materials in a planned order, in accordance with online meetings, and thus followed the principles of flipped approaches. This provided students with time and location flexibility, and teachers with time to clarify challenging content and support student learning. Moreover, the students were guided to use the LMS which was built to follow elements of SRL such as tool to monitor one's own progress and quizzes with automatic corrections and explanations. Additionally, the LMS contained all course material the students could use to practise along with the option to pursue other sources of information to aid their learning. Specific information on student interaction with the LMS are reported in results section.

Measures

Two questionnaires related to SRL were used in the LMS for dispositional learning analytics data. Questionnaires were mainly compiled using previously tested questionnaire models and their subscales. Inventory of Learning Styles (Vermunt 1994) was used to investigate the various elements of SRL using a five-point Likert scale (1=rarely, 5=always): (1) *self-regulation of learning process and results* (3 items, e.g. "I try to formulate the main points in my own words"), (2) *self-regulation of context* (4 items, e.g. "In addition to the syllabus, I study other literature related to the content of the course"), and (3) *lack of regulation* (3 items, e.g." I notice that I have trouble processing a large amount of subject matter"). *Task avoidance* was measured as a subscale of orientation with Strategy Attribution Questionnaire (Nurmi et al. 2022) using a six-point Likert scale (1=totally disagree, 6=totally agree; 3 items, e.g. "If I am expecting some difficulties, I usually find something else to do"). These measures have been used in previous studies (e.g. Hyppönen et al. 2019; Kiljunen et al. 2023). The cyclical phases model (Zimmerman 2000) theory was used as a basis for (1) *self-regulation* (4 items, e.g. "I design my schedule to achieve my goals"), and (2) *shared regulation* (3 items, e.g. "I know what and how my closest peers do during study periods") and were pilot tested for this study. These items were answered using a five-point Likert scale (1=rarely, 5=always). Moreover, subscales for *positive experience with LMS* (6 questions, e.g. "Own progress tool has helped me guide my learning") was adapted from Hirsto and colleagues 2022 and modified to HE context. *Learning time* (5 items, e.g. "I am very aware of my own ways of studying"), *user experience* (4 questions, e.g. 'LMS - environment was easy to use'), and *negative experience with LMS* (3 questions, e.g. "Using own progress tool has been frustrating") were applied versions from the same study. Answers were given using a six-point Likert scale (1=totally disagree, 6=totally agree).

Analysis for dispositional learning analytics data

Data analysis for dispositional learning analytics was conducted in four phases. First, we investigated internal consistency with Cronbach`s alpha (α) for reliability. Nunnally and

Bernstein's (1994) criteria ($α > 0.7$) was used to indicate adequate reliability. Second, mean sum variables were formed to represent a singular measured metric for all scales. Third, comparison between T1 and T2 was conducted using paired sample t-tests (e.g. Field 2018) to provide an accurate depiction of related variables of SRL. Fourth, dispositional learning analytics data (i.e. questionnaires) was used to make an indicator for history of pedagogical support. This indicator was then used to compare students with and without a history of pedagogical support. In accordance with Field (2018), an independent t-test with bootstrap was used to accommodate unrelated variables and increased sources of variance. Thus, this provide a more accurate analysis of aspects of SRL. Also, in phases three and four, bootstrap was used to compensate for small sample size and to provide a more accurate depiction. Cohen's (1977) d was used to assess effect size (*ES*) with Cohen's (1977) *d ES* estimates (< 0.2, no effect; 0.2–0.5, small effect; 0.5–0.8, medium effect; > 0.8, large effect). All analysis were made using SPSS version 27.

Analysis for learning analytics data

The data from students' actions in the LMS were grouped into sessions. A session was defined as an uninterrupted sequence of learning actions, where the time gap between two consecutive actions was no more than 5 minutes. Overly long sessions (70 clicks and longer, 98th percentile) were trimmed, following the methods of Saqr and colleagues (2023). The data were coded as follows to represent student actions more accurately: *Assignment*: graded task in the LMS for students; *Content*: handouts or similar learning content provided to the students in the LMS; *Video*: video content for students in the LMS; *End*: end page for lesson in the LMS; *Guide*: general instructions for the students in the LMS; *Instruction*: task or course instructions for the students in the LMS and Task: exercises for students to check for understanding of the content (e.g. multiple choice, usually checked automatically). In the coding, content and video content were differentiated, as according to earlier research the form of the content might be related to the way students use the content for their learning (e.g. Sahin et al. 2015). Sequence analysis was then used in conjunction with discriminant analysis (Ritschard et al. 2013) to show differences in learning sessions and subsequences between students with and without a history of pedagogical support. The analysis was performed using the R package TraMineR (Gabadinho et al. 2011). Finally, transitions and learning processes were visualised via process mining, using the R package pMineR (Gatta et al. 2017).

Results

Results from dispositional learning analytics data

Paired sample t-test results are reported in Table 1. First, the internal consistencies were adequate ($α > 0.7$) for the majority of mean sum variables, according to Nunnally and Bernstein's (1994) criteria. The learning time sum score was slightly lower in T2 (adequate in T1) but approaching the desired threshold; thus, we decided to keep this variable in the analysis. Second, in the comparison of T1 and T2 measurement points, four statistically

significant ($p < 0.05$) differences were identified: self-regulation of learning process and results, lack of regulation and shared regulation increased with small effect size (*ES*), and task avoidance decreased with medium *ES* between measurement points.

Only statistically significant difference with the same sum variables as in the Table 1 was found on the positive experience between students without (*M*=3.67, *SD*=1.03) and with (*M*= 4.28, *SD*=0.78) history of support ($M_{difference}$=0.60, *SE*=.26, *p*<0.01) with medium ES (d=0,61. This indicates that students with a history of pedagogical support experienced feedback from the LMS more positively than students without a history of pedagogical support. Thus, more information from learning analytics was sought.

	T1	T2	T1		T2		t-test results (bootstrap)			
	α	*α*	*M*	(*SD*)	*M*	(*SD*)	*M* difference	*SE*	*p*	*d*
Self-regulation of learning process and results	0.74	0.84	2.44	0.93	2.60	1.01	-0.16	0.08	0.04	-0.22
Self-regulation of content	0.71	0.78	2.92	0.79	2.85	0.82	0.07	0.06	n.s.	n.s.
Lack of regulation	0.77	0.80	2.30	0.72	2.50	0.83	-0.20	0.09	0.02	-0.25
Self-regulation	0.70	0.78	3.46	0.80	3.40	0.83	0.07	0.07	n.s.	n.s.
Shared regulation	0.78	0.76	2.38	1.35	2.59	1.37	-0.21	0.10	0.03	-0.23
Task avoidance	0.84	0.93	3.22	1.29	2.44	1.35	0.78	0.11	<0.01	0.75
Learning and time	0.70	0.66	3.73	0.76	3.83	0.68	-0.10	0.07	n.s.	n.s.
User experience	N/A	0.89								
Positive experience of LMS	N/A	0.91								
Negative experience of LMS	N/A	0.90								

Note: T1 = measurement before course, T2 = measurement after course *α* = Cronbach's alpha, *M* = Mean, *SD* = Standard Deviation, *p* = significance, *d* = Cohen's d, n.s. = non-significant. Bootstrapping was used in t-tests.

Table 1. Changes between measurements before the course (T1) and after the course (T2), paired sample t-tests.

Results from learning analytics data

Table 2 presents the descriptive statistics of students' actions in the LMS for those with (*N* = 22) and without (*N* = 86) a history of pedagogical support. Apart from Content, all mean values of the measured actions (in order of performance frequency) of *Task*, *Instruction*, *Video*, *End*, *Guide* and *Assignment* were higher for students without a history of pedagogical support. While it should be noted that the overall differences were small and, in some actions, nearly negligible (i.e. End and *Instruction*), action frequencies between measured groups differed.

	No history of support			History of support		
	M	(*SD*)	Total	*M*	(*SD*)	Total
Assignment	3.95	4.03	340	3.36	3.90	74
Content	101.52	108.53	8.731	109.59	119.36	2.411
End	21.59	23.22	1.857	19.91	21.26	438
Guide	7.90	11.21	679	5.91	7.36	130
Instruction	25.08	28.06	2.157	23.86	27.10	525
Task	50.26	55.15	4.322	47.18	54.17	1.038
Video	25.16	29.98	2.164	21.95	25.40	483

Note: *M* = Mean, *SD* = Standard Deviation, *Total* = total number of actions in group. Also, Assignment = graded task, Content = handouts or other types of content, End = end page for lesson, Guide = LMS instructions, Instruction = Task or course instructions, Task = exercise, Video = video content.

Table 2. Descriptive statistics of students' actions in the LMS by group.

Sequence analysis

The sequence analysis in Figure 2 presents the evolution of the share of actions throughout each time point of students' learning sessions. Comparisons between groups display differences in the distribution of *Content* as well as *Guide*, *Instruction* and *End*. These actions were more common in the group without a history of pedagogical support when compared to the more widespread nature among students with a history of pedagogical support.
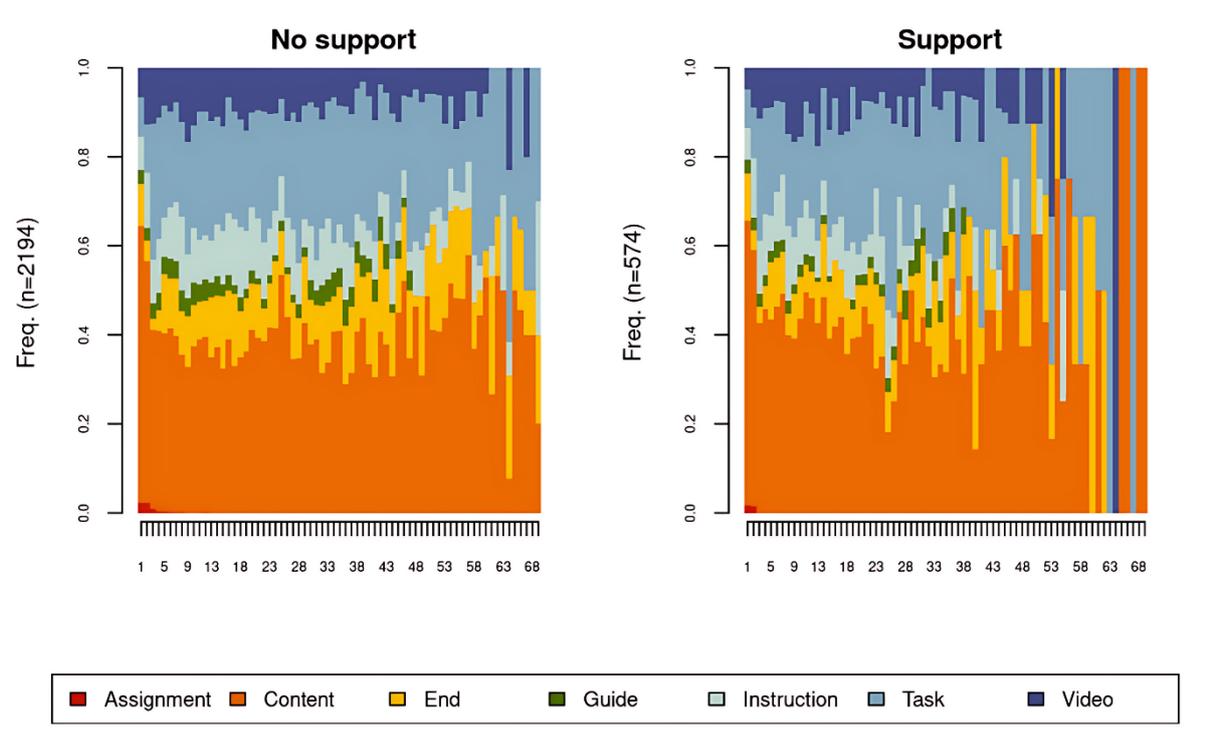
Figure 2. Sequence distribution plots of the learning sessions by support group. Vertical column represents a learning session and horizontal column sequence of named factor. Assignment = graded task, Content = handouts or other types of content, End = end page for lesson, Guide = LMS instructions, Instruction = Task or course instructions, Task = exercise, Video = video content.

Discriminant sequence analysis

The discriminant sequence analysis shows the subsequences that differ significantly between the two groups using a chi-squared test with highlighting based on Pearson's residuals. As presented in Figure 3, *Content* concluded with end of action (%) in multiple processes, with *P=0.01* and *P=0.05* among students with a history of pedagogical support. Students without a history of pedagogical support showed only a decreased number of transitions compared to students with a history of pedagogical support, represented as *End > Content – Content > % (p=0.05)*. Other subsequences were statistically non-significant.
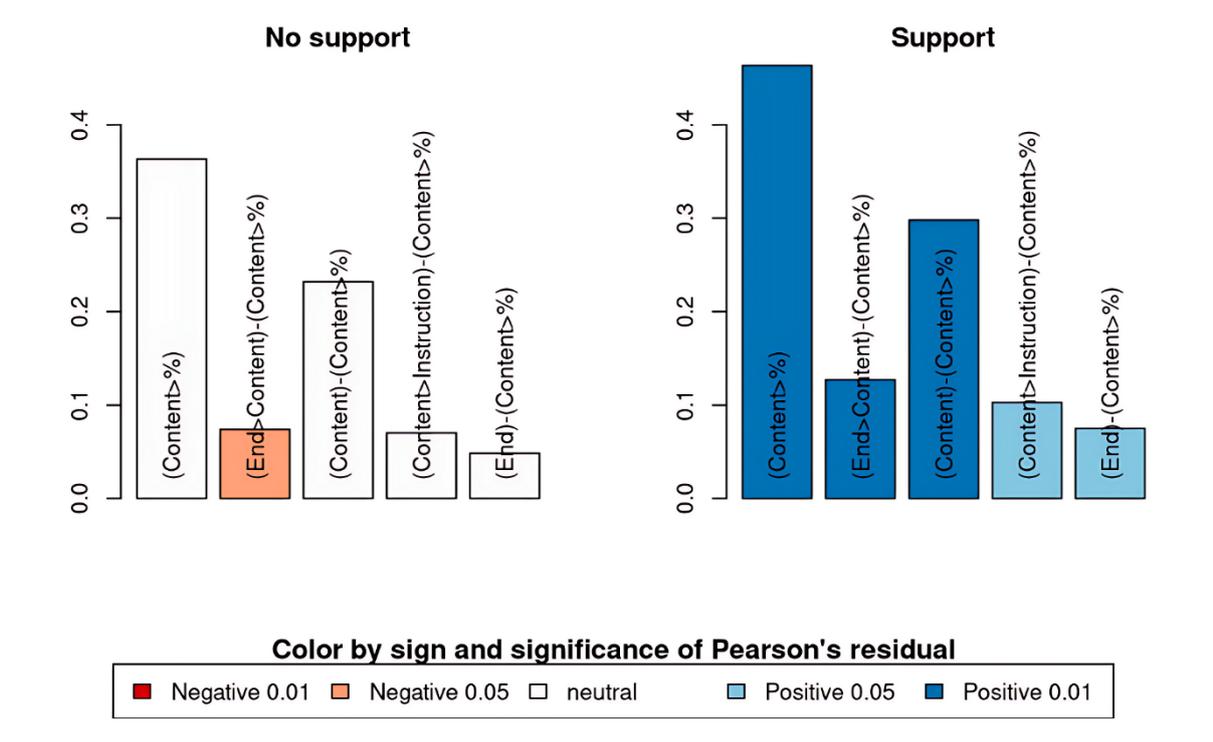
Figure 3. Ten most discriminating subsequences by their discriminating power for each support group. < > = movement towards action, - = repeated action, % = end of action, Content = handouts or other types of content, End = end page for lesson, Instruction = Task or course instructions, Video = video content.

Process mining

Process mining was used to visualise the learning process and to explore the transitions between LMS actions and how they differed between the two groups. Figure 4 shows the process map of students' sessions. The plot complements the insights from previous analyses and plot indicates that transitions to *Content* from Task (0.22/0.27), *Video* (0.54/0.62) or *End* (0.66/0.74) were more frequent (with a difference in probability > 0.05) for the students without a history of pedagogical support than for those with a history of pedagogical support. The transition between *End* and *Task* was more likely for students with a history of pedagogical support, as was clicking repeatedly on *Assignment*.
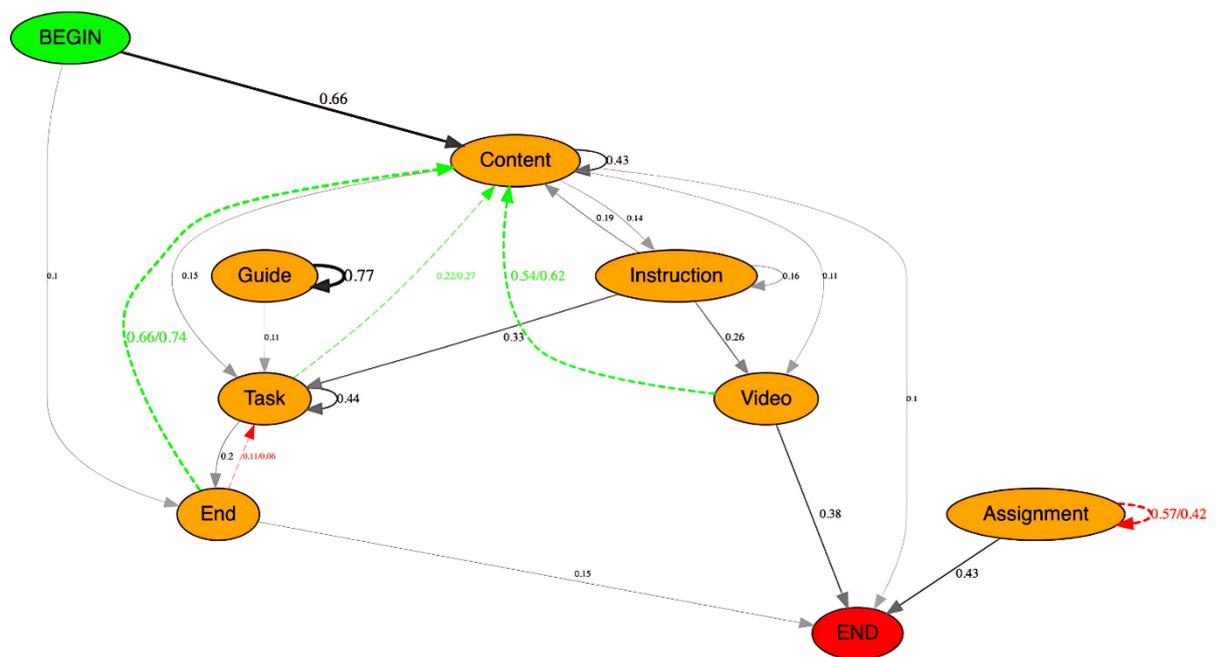
Figure 4. Distance graph between the FOMM of the student transition probabilities by groups (red=history of pedagogical support is higher, green=no history of pedagogical support is higher, grey=non-sig. differences. END= end of process or session) with p < 0.05.

Discussion

We sought to investigate higher education (HE) students' self-regulated learning (SRL) and to compare students with a history of pedagogical support to students without a history of pedagogical support. Based on our findings, self-regulation of process and results, lack of regulation and shared regulation were raised, and task avoidance reduced, for all students when comparing the beginning and the end of the course. Specifically, after the course, students with a history of pedagogical support had a more positive experience with the learning management system (LMS), while all other factors were non-significant. Also, learning analytics data indicated statistically significant, yet minor, differences in behaviour between groups with and without a history of pedagogical support.

When studying changes in SRL elements for all students, self-regulation of learning process and results increased in mean value between the first and last measurement points, with small effect size. While the change was small, it indicated that students' ability to regulate the process and goal setting were better after the course than before. This is in line with the findings of Lai and Hwang (2016), in which the flipped classroom environment (that includes SRL support) increased elements of self-regulation of the learning process and results (i.e. goal setting, task strategies and time management). This could be a result of gathering experience and expertise (Vermunt & Vermetten 2004) and learned as a part of social interaction or personal discovery (Zimmerman 2000). This suggests that HE teachers could effectively aid students' development of learning process through SRL supported flipped environment and as such offer practical means for group-based learning support.

Lack of regulation increased in mean value with small effect size. At the same time, measured self-regulation also lowered slightly, but was not statistically significant. Although changes in lack of regulation and self-regulation are small, they should not be dismissed. Moreover, as cited by Van Bragt and colleagues (2011), lack of regulation combined with ambivalence (i.e. mixed dispositions on the subject at hand) could affect course credit accumulation and increase the risk for student dropout. As pointed out by Kiljunen and colleagues (2023), students with support are more prone to having lower self-regulation and self-efficacy. This combined with our findings indicates the need for SRL support as a part of course curriculum to minimize differences between aforementioned groups.

Opposite the lack of regulation, shared regulation increased in mean value with small effect size. Panadero and Järvelä (2015) stated that while more research is needed, socially shared regulation appears beneficial to group performance and thus should be promoted by teachers. Notably, this is encouraged in flipped environments (e.g. Toivola et al. 2017). Given that our methods were not equipped to determine whether the use of the aforementioned environments is a factor, such cannot be ruled out and, in turn, highlights the need for further study. It should also be considered that shared regulation is not the same as collaborative regulation, and one way to construe the difference is to incorporate collaboration regulation as a part of shared regulation, since it does not require balanced regulatory skills within the group (e.g. Panadero & Järvelä 2015). In other words, collaborative regulation could be seen as a scaffold for the development of regulatory skills (Perry & Rahim 2011). This ideology can also be supported by the social cognitive perspective, where the levels of skill acquisition move from observation towards self-sourcing (i.e. from emulating and self-controlling, to finally regulating skill use) (Schunk & Zimmerman 1997; see also Zimmerman 2000).

Task avoidance displayed the largest change, with an effect size closer to large. This result is supported by previous studies conducted in flipped learning environments (e.g. Sointu et al. 2023a). As pointed out by Nurmi and colleagues (2003), task avoidance seems to be a predictive factor of academic performance and could lead to both lowered effort on study tasks and lowered academic satisfaction. Also, Hirsto and colleagues (2019) concluded that high task avoidance, combined with a lack of self-regulation skills, could pose a challenge for student success in flipped learning environments. As task avoidance could also lead to a cumulative cycle of low performance (Nurmi et al. 2003), decreasing its occurrence among all students could potentially help to reduce future support needs.

Interestingly, when comparing groups (i.e. students with and without a history of pedagogical support) in the last measurement point, only one statistically significant result was found. However, because of the small sample size, caution is advised when drawing conclusions. Dispositional learning analytics data indicates that feedback from the LMS was experienced more positively by the group that had a history of pedagogical support, with a mean difference of 0.6 with medium effect size. This is in line with previous research, where LMS feedback was connected to a positive effect on student dispositions (e.g. Thai et al. 2023) and learning processes (Yilmaz 2022). Also, the overall results might imply that the LSM system worked as a complementary feedback system, which is in line with the basic ideology of flipped learning (FL), where teacher time is devoted to student-centred support and collaborative learning (Sointu et al. 2023a). This is important to knowledge particularly as the students with support needs seems to favour collaborative practices in flipped context (Kiljunen et al. 2023).

Reviewing the differences in group activities found in the learning analytics data, sequence analysis – in conjunction with discriminant analysis and process mining – showed that, while small, differences between groups existed within the researched learning sessions. Because of the sample size, generalisations should be made with caution. That being said, differences in trace log data could indicate the effects of flipped environments, which is supported by the positive experience of LMS among students with a history of pedagogical support. As pointed out by Nouri (2016), flipped classroom seems to increase student learning and to produce a more active participation among all students. Also, student dispositions indicated an appreciation for the flexibility and self-determined pacing in flipped classroom (Nouri 2016), which could be construed as a prerequisite condition for SRL implementation regarding self-regulated action (e.g. Panadero 2017).

Among students with a history of pedagogical support, Content concluded with end of action (%) in multiple processes (see figure 3), with P=0.01 and P=0.05. Such could indicate increased persistence and a lack of learning strategies. While this is only an educated guess, it is supported by Dunkle and Yantz's (2021) notion that a flipped pedagogical approach can increase student persistence, and by Vermunt and Vermetten's (2004) observation that indicated a correlation between experience and differentiations of learning strategies. Similarly, in our results, the group without a history of pedagogical support used LMS elements more extensively, whereas the group with a history of pedagogical support had a more narrow approach. Because of the limited amount of research on the history of pedagogical support in HE, further explorations are needed.

As practical implication, our results suggest that course designs (e.g. flipped classroom) can enable development of SRL skills, combat task avoidance and as such offer general support for all students. As self-regulatory skills are not equal between supported and non-supported students (Kiljunen et al. 2023) the need for different ways to support students SRL development increases. As mentioned before, the use of LMS seems to be varied between groups with and without history of pedagogical support. While group without history of support used LMS more extensively, group with history of pedagogical support experienced LMS more positively. This could indicate that LMS functions as a self-imposed differentiation method. Moreover, raised self-regulation of the learning process and results and lowered task avoidance further validate the success in support within the studied course design.

Limitations and future research

There are five limiting factors in our study that are closely tied to our future study suggestions.

First, the questionnaire data do not specify when or how pedagogical support was received. Second, this study focuses on examining differences between groups rather than differences in previously received pedagogical support. As such, history of pedagogical support is only used as a dichotomous factor in the data. Third, the use of online trace log data was limited to participants with consent to collect and merge both learning analytics and dispositional learning analytics data. Furthermore, the data comprised only two course settings in similar learning environments. A larger scale study including multiple course settings could provide a more comprehensive student sample and therefore more generalisable results. Fourth, data was collected via self-report questionnaires, where support questions were specified to include only pedagogical support. As indicated previously, learning problems are not the only

reported challenges of studying in HE (e.g. Korkeamäki and Vuorento 2021), and enlarging the scope of future research on the need for pedagogical support could provide more accurate results. Fifth, a deeper understanding of the changes in students' SRL could be achieved by using quasi-experimental, qualitative method or mixed-method research designs. These strategies would enable more accurate research to characterise cause and effect between variables (e.g. teaching methods or learning environments), explore student dispositions towards learning and SRL teaching, as well as increase information about relevant factors.

Conclusion

Longitudinal comparisons made with paired sample t-tests seem to imply that the courses and, as an extension, the learning environment have succeeded in promoting the SRL skills of HE students between measurement points. When independent sample t-tests were conducted to compare groups with and without a history of pedagogical support, only one difference was statistically significant, and non-significant results showed only small differences in mean values. While this seems to imply that differences between groups are non-existent, learning analytics data suggests otherwise, indicating the need for further study. Moreover, this study suggests that support through learning design (i.e. flipped context and LMS) can affect the development of SRL skills of students with and without history of pedagogical support and as such should be thoroughly investigated.

Acknowledgments

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