Technology-Enhanced and Student-Centered Learning as a Method to Foster Students' ICT Competence and Problem Coping Skills

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***Abstract*—The aim of this research-to-practice full paper is to present the results of most recent analyses of the long-term school pilot project named "learning office approach". The learning office represents an alternative branch of a technology-oriented vocational secondary school in Europe encompassing the grades K9–K13 and has been implemented at the IT department in 2016. Students of a learning office cohort have flexible course schedules allowing them to choose between several subjects on a daily basis, which in turn enables differentiation and individualization: Students seeking help or striving to deepen their knowledge and skills may visit chosen subjects more often. Since learning office subjects do not rely on lectures and direct instruction, teachers become facilitative coaches helping students become self-responsible learners and study in a self-driven, self-directed way, which in turn fosters their 21st century skills.**

The COVID-19 pandemic and resulting emergency remote teaching strategies demonstrated the supreme importance of digital competences and self-efficacy: Students were abruptly required to work autonomously with digital systems and study at home in a self-driven way. Since the learning office heavily relies on students working with digital educational material and tools in a self-directed and student-centered way, the question arises if learners show indications of increased ICT competences and self-efficacy in the learning office.

This paper evaluates the interplay of students' self-reported ICT skills, school-specific self-efficacy, and academic performance in the learning office approach and traditional classrooms. Based on an extensive literature review, a questionnaire was developed and distributed among all 552 students of the grades 9–13 and students' final grades of the winter term 2021/22 were analyzed. The results show a significant increase in self-perceived problem coping skills and ICT competences in the learning office approach, including the sub-scales "general ICT self-concept", "communication", "process and store", and "generate content". We conclude that technology-enhanced student-centered approaches, such as the learning office, are a viable method to foster students' 21st century digital skills.

***Index Terms*—learning office, 21st century skills, ICT skills, student-centered learning**

I. Introduction

There is no doubt that the 21st century is shaped by digitalization and the increasing adoption of digital technologies in developed countries. Consequently, the resulting transition from a production-oriented world towards a knowledge-based society has substantially and lastingly changed the knowledge and skills that are expected from the workforce [1]. Working in a fast-paced, technology-supported, and information-based digital era requires individuals to learn how to apply new digital technologies, critically assess and use digital information, collaborate in virtual environments, as well as work with and produce digital media. However, these kinds of skills are not only essential in the context of work, but also to contribute to a responsible digital society.

Hence, educational facilities should consider and teach these kinds of "future skills" to prepare students for being a responsible member of the digital society and workforce [2]. Yet, a lot of reports and studies suggest a gap between the non-cognitive skills of graduates and the skills expected by employers (see, e.g., [3]–[7]). Possible reasons for this were found to include a lacking integration of these competences in the curriculum, insufficient teacher training, and a missing strategy to include novel methods of teaching and learning [8].

Approaches to foster students' 21st century skills are self-directed learning and student-centered education (see, e.g., [9]–[12]): By putting students at the center of learning and transferring the responsibility of the learning process to the learner themselves, they take responsibility for their own learning and are able to develop and improve essential skills, such as self-management, digital literacy, communication, critical thinking, and problem solving.

This paper provides insight into a long-term pilot project called "learning office" introducing student-centered classrooms to a vocational upper secondary school in the field of computer science education. The goal of this study was to analyze students' learning outcomes compared to traditional classrooms and investigate whether students experiencing the learner-centered approach report differences regarding their ICT skills and self-efficacy.

A. Related Work

The Global Partnership for Education analyzed the integration of 21st century skills in education sector plans as well as implementation grants of 15 developing countries

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and published their findings in a recent report [13]. Based on the definition of Binkley et al. [14], they defined 21st century skills as “abilities and attributes that can be taught or learned in order to enhance ways of thinking, learning, working and living in the world” [13, p. V], which includes non-cognitive competences such as critical thinking, learning to learn, communication, information and ICT literacy, life skills, and responsibility [13]. They conclude that while most countries have clear goals and visions about the integration of 21st century skills in the educational system, there seems to be a gap in the concrete implementation of these competences in educational practice (see also, e.g., [8]).

This raises the question: How can 21st century skills be taught? According to the literature, these kinds of skills are not an “addition” or “alternative” to content-related knowledge and skills, but are rather best acquired together with them [8], [15], [16]. A common approach to foster the development of 21st century skills are methods of student-centered learning (see, e.g., [10]–[12]), which typically rely on self-direction. Self-directed learning has been found to correlate with several components of 21st century skills, including management and evaluation of information, collaboration, problem solving, and communication, as found in a large-scale survey by van Laar et al. [9]. The learning office project extensively relies on student-centered learning [17], [18] to foster learners’ 21st century skills [2], [19] and showed indications of increasing students’ reflective thinking as well as their self-reported critical thinking, self-efficacy, and personal responsibility [12].

The important contribution of digital competences and ICT skills to 21st century skills is demonstrated by the fact that “digital literacy” is one of the three skill sets of Trilling’s and Fadel’s framework for 21st century learning [1] and has been recently strikingly highlighted by the COVID-19 pandemic and resulting emergency remote teaching strategies. Recent literature suggests an even stronger integration of digital competences and 21st century skills due to them being tightly interwoven, introducing the term “21st century digital skills” (see, e.g., [20]–[22]). The acquisition of ICT skills and digital competences is a central and cross-cutting aspect of the learning office approach [19], since learning office courses rely on a blended-learning concept and deliver most of the content and exercises using a learning management system. Hence, students are used to communicating and collaborating using digital media and work with digital information.

B. Learning Office Project

The learning office project has been started in 2016 by introducing a new branch to the IT department of the TGM, a higher vocational upper secondary school (K9–K13) in Europe [17], [23]. Students may therefore decide between traditional classrooms and the learning office approach when they apply for a school place. Two learning office cohorts and two traditional cohorts are formed each school year, which allows for systematic evaluations of this pilot project. The learning office now encompasses the grades 9–13, allowing for holistic comparisons of both approaches.

TABLE I
EXEMPLARY CLASS SCHEDULE OF A LEARNING OFFICE COHORT [2], [17], [19], [27], [28]

Lesson	M	Tu	W	Th	F
1	TS	TS		TS	TS
2	TS	TS		TS	TS
3	GE	GE	TS	GE	GE
4	GE	GE	TS	GE	GE
5					
6			GE		
7			GE		
8			GE		
9			GE		
10					

Note. TS: technical subjects,
GE: subjects of general education

The learning office is based on the approach by Margret Rasfeld [24], [25]. She successfully implemented this concept at her school in Berlin at the grades 7–10 for general education subjects. We extended her approach to computer science education, thus also including technical subjects like software development. This is also in accordance with the work of Carl Rogers, an important pioneer in the field of student-centered learning, who suggested that “self-determined learnings are just as appropriate in a ‘hard’ science course as in the so-called ‘soft’ subjects” [26, p. 93].

The learning office approach provides students with a flexible course schedule, allowing them to attend certain subjects based on their liking on a daily basis, enabling individualization and differentiation (see, e.g., [2], [17], [19], [27]). For instance, students having troubles understanding a topic in mathematics may visit the learning office for mathematics more often to receive additional support, while students striving to deepen their knowledge and skills in programming may lay their focus on software development to work on advanced topics. Table I shows a typical class schedule of a learning office cohort, allowing students to choose between several technical subjects and general education subjects during lessons labeled “TS” and “GE” respectively.

Cohorts of different grades may share the same room, enabling peer coaching and learning. Students study using self-explanatory course material and work on exercises as well as projects using problem- and project-based learning, which is also rooted in person-centered learning: “It appears that if we desire to have students learn to be free and responsible individuals, then we must be willing for them to confront, to face problems” [26, p. 148].

Previous work, especially focusing on case studies in the context of the subjects applied mathematics and software development, showed that learning office students achieve equal learning outcomes after the first school year, which is needed to get adjusted to the self-driven way of learning [2], [17], [19]. It was also found that students experiencing the learning office approach reported to cooperate more frequently [17], like going to school more [17], are more satisfied with their classrooms as well as teachers' support [19], and showed indications of increased 21st century skills [12]. However, the connection between student-centered, technology-enhanced learning offices and students' ICT skills has not yet been formally evaluated. Furthermore, a post-lockdown survey, i.e. after returning to permanent on-campus teaching, of students' grades in both approaches is still outstanding.

C. Research Questions

This paper aims to close the mentioned gaps and deals with the following research questions:

RQ1: Do learning office students still achieve equal learning outcomes compared to their peers of traditional classrooms after returning to on-campus teaching?

RQ2: To what extent are student-centered learning offices associated with students' self-perceived ICT skills and self-efficacy in comparison to traditional classrooms?

RQ3: What is the role of students' perceived self-efficacy in the interplay of academic achievement and self-perceived ICT skills?

II. Materials and Methods

To address the posed research questions, we chose a quantitative approach to be employed within the context of the learning office study, which uses an observational study design [17]. Since we combined multiple types of data analyzing different aspects, namely performance data and self-reported metrics, this study used a mixed method approach (see, e.g., [29], [30]). The following quantitative research instruments were used:

Average Grade Analysis: We anonymized and collected students' report cards of the winter term 2021/22 to calculate their average grade of all subjects by using a mapping commonly used in Austria [19]: $A \rightarrow 1, B \rightarrow 2, C \rightarrow 3, D \rightarrow 4, F \rightarrow 5$. To allow for a fair comparison, of the total of 552 records, we only considered students who regularly completed the previous school year, therefore excluding students who had to repeat a school year or switched department, resulting in a final data set of 510 students.

Survey on Self-Perceived ICT Competence and Self-Efficacy: After an extensive literature review on approaches to estimate ICT competence and students' self-efficacy, we decided to use two proven and validated questionnaires. To estimate our students' self-perceived digital competence, we used the "ICT Self-Concept Scale (ICT-SC25)" [31] by Schauffel et al., which is a 25-item questionnaire available in English and German. Based on the European DigComp 2.1 framework [32], they developed 25 statements to be rated on a 6-point Likert scale from "Strongly disagree" to "Strongly agree" and validated their instrument with five independent samples with a total sample size of 2024.

Jerusalem and Schwarzer intensively researched the ways individuals perceive their self-efficacy and published multiple validated instruments to estimate it [33]. We decided to use their method to measure school-specific self-efficacy (WIRKSCHUL), which was developed in a research project with 2000 students and consists of 13 German statements specifically designed for students to be rated on a 4-point scale from "Completely disagree" to "Completely agree".

We invited all of our 552 students to answer the created online survey voluntarily from 29 January 2022 to 27 February 2022, including one reminder sent out on 16 February 2022. After an initial screening of the 158 responses, we filtered out incomplete data records and anonymized the data set, resulting in an overall sample size of 110. This corresponds to a response rate of 19.9%.

For the analysis, we calculated the mean of the equally weighted items of the respective sub-scale and rescaled it to an index of the range $[0, 1]$, with 0 being the lowest rating and 1 the highest.

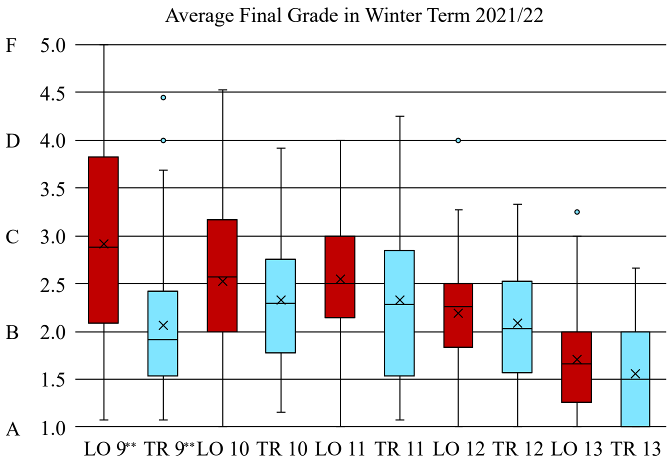
III. Results and Interpretation

A. Reliability

To investigate whether the applied research instruments return reliable results in our context, we revalidated the reliability of the final data set using Cronbach's alpha [34]. This was important for the ICT-SC25 in particular since the original research was carried out with adults, while most of our students are in the age range 14–19. The reliability analysis returned for each of the five sub-scales of the ICT-SC25 a raw alpha value between 0.79 and 0.9, while the alpha value of the self-efficacy scale WIRKSCHUL was 0.84. Since nearly all of the (sub-)scales were above 0.8, a good level of reliability is assumed [35].

B. Average Grade Analysis

Fig. 1 presents students' average final grade upon completion of the winter term 2021/22; the summary is shown in Table II. The results confirm previous findings [2], [17], [19], [27] stating that learning office students need about one or two semesters to get used to the new way of learning, which is also reflected in their final grades: At the 9th grade, a significant difference could be found in the location parameter using a Kruskal-Wallis rank sum test with $p = 1.3 * 10^{-6}$. Furthermore, the distributions showed different patterns in terms of variability: While the distribution of the average grade was rather symmetric and widely spread in the learning office, the grades distribution in traditional classrooms was denser, but rather right-skewed towards the failing grade, indicating more outliers. Since a Shapiro-Wilk test for normality provided enough evidence to reject the assumption of normality in the traditional approach with $p = 2.5 * 10^{-4}$, we performed a Levene's test, which is more robust against non-normal distributions than an F-test, to test for equity of variances. Our observation was found significant indicated by a p-value of $2.0 * 10^{-4}$. This suggests that learning office students tend to focus on doing the basic exercises in their first year, thus reaching rather C-grades, while students of traditional classrooms also do advanced exercises. This seems natural, since learning office students also need to develop and sharpen their non-cognitive skills in their first year.



Note. Grades are scaled from 1 (A) to 5 (F). $^{**}p < 0.01$.

Fig. 1. Students' Average Final Grades in Traditional Classrooms (TR) and the Learning Office (LO) in the Winter Term 2021/22 at the Grades 9–13

TABLE II
SUMMARY OF STUDENTS' AVERAGE FINAL GRADES IN TRADITIONAL CLASSROOMS (TR) AND THE LEARNING OFFICE (LO) IN THE WINTER TERM 2021/22 AT THE GRADES 9–13

Cohort	N	Min	Q1	Med	Mean	Q3	Max	SD	IQR
LO 9**	60	1.07	2.14	2.88	2.92	3.81	5.00	1.03	1.67
TR 9**	66	1.07	1.55	1.92	2.06	2.38	4.45	0.70	0.83
LO 10	42	1.00	2.09	2.57	2.52	3.13	4.53	0.85	1.04
TR 10	55	1.15	1.81	2.30	2.33	2.76	3.92	0.69	0.95
LO 11	43	1.00	2.18	2.50	2.54	2.96	4.00	0.65	0.79
TR 11	51	1.07	1.59	2.28	2.33	2.85	4.25	0.82	1.26
LO 12	32	1.00	1.83	2.26	2.19	2.50	4.00	0.65	0.67
TR 12	54	1.00	1.59	2.04	2.09	2.49	3.33	0.64	0.90
LO 13	49	1.00	1.30	1.66	1.71	2.00	3.25	0.58	0.70
TR 13	58	1.00	1.00	1.50	1.56	1.98	2.66	0.51	0.98

Note. Grades are scaled from 1 (A) to 5 (F).
LO X: Cohorts of the learning office of grade X,
TR X: Cohorts of the traditional approach of grade X.
$^{**}p < 0.01$.

After the first year, students seem to have adjusted to self-directed learning and achieve equal academic performance – no significant differences could be found in the variability or location parameter at the grades 10–13. This suggests that after the return from online learning to on-campus teaching, learning office students performed equally after their first school year.

C. Self-Perceived ICT Competence

The results of the survey of students' ICT self-concept [31] by the used teaching approach are presented in Fig. 2; a detailed summary can be found in Table III. Students of the learning office reported a notably higher total ICT self-concept with a mean score of 0.85 compared to 0.79 in the traditional approach. This difference was found significant in a Welch's two-sample t-test returning $p = 0.0154$.

The general ICT self-concept was also significantly higher in the learning office approach, reaching a mean index of 0.90 in the learning office compared to 0.85 in traditional classrooms ($p = 0.0329$). On the "communication" sub-scale, learning office students reached 0.89, while students in the traditional approach scored 0.84 – this was also found significant with $p = 0.0416$. A similar pattern could be observed regarding students' ability to process and store digital data: While the mean index was 0.85 in the learning office, the same metric was 0.79 in the traditional approach, once again significant with $p = 0.0277$.

The greatest difference by far was found on the "generate content" sub-scale, on which learning office students scored 0.84 on average, while their peers of the traditional approach reached a mean index of 0.76. This difference was found highly significant, indicated by $p = 0.0090$.

Although the sub-scales "safe application" and "solve problems" revealed notable tendencies towards higher scores in the learning office, the differences were not significant due to the high variability in both approaches.

These findings showed a clear association between a student-centered approach to teaching and increased self-perceived ICT skills compared to traditional teaching. As ICT and media literacy are seen as a part of 21st century skills (see, e.g., [1]) or being tightly coupled with them (see, e.g., [20]–[22]), student-centered and self-directed learning seem to be not only a method to foster 21st century skills as suggested by the literature (see, e.g., [9]–[12]), but also to specifically foster students' ICT competence. This assumption seems natural in the context of this study, since students of the learner-centered learning office approach work with, communicate using, and create digital media and information – even more than their peers of traditional classrooms, who are also experiencing a technical formal education, but rather teacher-centered.

D. Perceived Self-Efficacy

Fig. 3 shows students' perceived self-efficacy using the WIRKSCHUL scale [33] including one sub-item representing their problem coping ability in both approaches. Further details can be found in Table III. Although there seemed to be a slight tendency of learning office students being more confident in their self-efficacy, this difference was not found significant.

However, upon closer inspection of the items of the self-efficacy scale, an interesting observation could be made: The second item of the WIRKSCHUL scale [33] asking students whether they think that they are able to cope with problems by themselves has been answered by learning office students notably more confidently than by their peers of traditional teaching, reaching a mean index of 0.77 compared to 0.66. This difference was found highly significant with $p = 0.0074$ using a Kruskal-Wallis rank sum test.

Hence, the results suggest that the learning office approach especially fosters one aspect of the learners' self-efficacy: their ability to cope with problems. This is also consistent with Carl Rogers' theory of the person-centered approach, claiming that a person-centered climate leads to coping "with the problems of life more adequately and more comfortably"

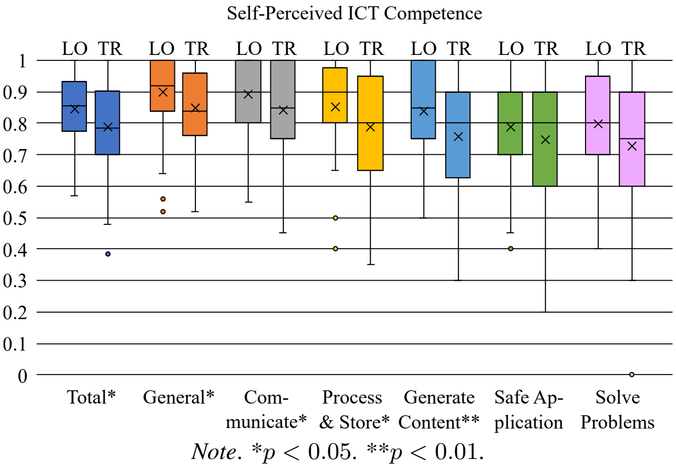


Fig. 2. Students' Self-Perceived ICT Competence Using the ICT-SC25 [31] in Traditional Classrooms (TR) and the Learning Office (LO)

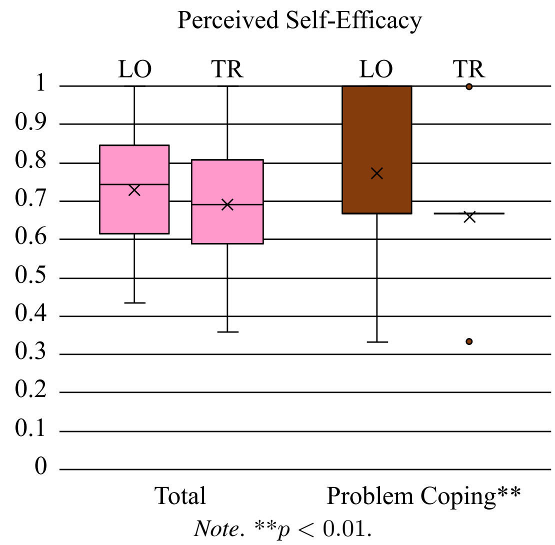


Fig. 3. Students' Perceived Self-Efficacy Using the WIRKSCHUL Scale [33] in Traditional Classrooms (TR) and the Learning Office (LO)

[36, p. 38]. This finding is also not surprising since the learning office is specifically designed to foster students' self-reliance using self-directed learning, thus relying on their problem solving skills and problem- as well as project-based learning. This confirms previous research, which showed an increase in learning office students' self-efficacy using a different research instrument [12].

E. Correlations

To analyze the interplay of students' perceived ICT competence and self-efficacy, we calculated the correlations between the used (sub-)scales and students' final average grade as well as their grades in the subjects software development, applied mathematics, German, English, and physical education, since students had these subjects in all of their five years at our school. Since the underlying data are based on an ordinal scale,

TABLE III
SUMMARY OF STUDENTS' SELF-PERCEIVED ICT COMPETENCE AND SELF-EFFICACY USING THE ICT-SC25 [31] AND WIRKSCHUL SCALE [33] IN TRADITIONAL CLASSROOMS (TR) AND THE LEARNING OFFICE (LO) AT THE GRADES 9–13

Factor	Approach	N	Min	Q1	Med	Mean	Q3	Max	SD	IQR
ICT Total*	LO	57	0.57	0.78	0.86	0.85	0.93	1	0.10	0.14
	TR	53	0.38	0.71	0.78	0.79	0.90	1	0.14	0.19
General*	LO	57	0.52	0.84	0.92	0.90	1.00	1	0.11	0.16
	TR	53	0.52	0.76	0.84	0.85	0.96	1	0.13	0.20
Commun-icate*	LO	57	0.55	0.80	0.90	0.89	1.00	1	0.11	0.20
	TR	53	0.45	0.75	0.85	0.84	1.00	1	0.14	0.25
Process & Store*	LO	57	0.40	0.80	0.90	0.85	0.95	1	0.14	0.15
	TR	53	0.35	0.65	0.80	0.79	0.95	1	0.17	0.30
Generate Content**	LO	57	0.50	0.75	0.85	0.84	1.00	1	0.14	0.25
	TR	53	0.30	0.65	0.80	0.76	0.90	1	0.18	0.25
Safe Application	LO	57	0.40	0.70	0.80	0.79	0.90	1	0.15	0.20
	TR	53	0.20	0.60	0.80	0.75	0.90	1	0.21	0.30
Solve Problems	LO	57	0.40	0.70	0.80	0.80	0.95	1	0.16	0.25
	TR	53	0.00	0.60	0.75	0.73	0.90	1	0.22	0.30
Self-Efficacy Total	LO	57	0.44	0.62	0.74	0.73	0.85	1	0.14	0.23
	TR	53	0.36	0.59	0.69	0.69	0.79	1	0.16	0.21
Problem Coping**	LO	57	0.33	0.67	0.67	0.77	1.00	1	0.22	0.33
	TR	53	0.33	0.67	0.67	0.66	0.67	1	0.21	0.00

Note. LO X: Cohorts of the learning office (grades 9–13), TR X: Cohorts of the traditional approach (grades 9–13). $*p < 0.05$. $**p < 0.01$.

we used Spearman's rank correlation coefficient [37] for the correlation analysis.

1) ICT Competence: We found several interesting correlations regarding students' self-perceived ICT competence using the ICT-SC25 [31]:

- ICT sub-scale "General" and grade in software development: The general ICT self-concept scale was found to correlate with the subject software development significantly with $r_s = -0.21$ and $p = 0.0271$. Hence, students who rated themselves better in terms of general ICT competence tended to have a better grade in software development, which is a reasonable connection, since students have to work with digital media and, particularly, interactive development environments in software development.
- ICT sub-scale "Generate content" and grade in English: We observed another significant correlation between students' self-perceived ability to generate digital content and their grade in English, indicated by a correlation coefficient $r_s = -0.20$ and $p = 0.0383$. This association also seems natural, indicating that students who feel confident in creating digital media, including text documents, also tend to receive better grades in English.
- ICT and self-efficacy: The total score of the ICT-SC25 including all of its sub-scales correlated significantly with students' perceived self-efficacy using the WIRKSCHUL scale [33]. The highest correlations could be found with the total scale as well as the "general" sub-scale with $r_s = 0.35$ ($p = 1.8 * 10^{-4}$) and $r_s = 0.35$ ($p = 1.6 * 10^{-4}$) respectively.

2) Self-Efficacy: Table IV shows the results of our correlation analysis regarding students' self-efficacy. Due to the dis-

TABLE IV
CORRELATIONS BETWEEN STUDENTS' GRADES, SELF-PERCEIVED ICT COMPETENCE, AND SELF-EFFICACY USING THE ICT-SC25 [31] AND WIRKSCHUL SCALE [33]

	Self-Efficacy Total	Problem Coping
	r_s (p)	
Average Grade	-0.34 ($3.4*10^{-4}$)	-0.32 ($5.9*10^{-4}$)
Software Development	-0.22 ($2.2*10^{-2}$)	-0.37 ($8.8*10^{-5}$)
Applied Mathematics	-0.33 ($4.2*10^{-4}$)	-0.26 ($7.2*10^{-3}$)
German	-0.21 ($3.2*10^{-2}$)	-0.23 ($1.4*10^{-2}$)
English	-0.28 ($3.5*10^{-3}$)	-0.26 ($5.5*10^{-3}$)
Physical Education	-0.31 ($1.2*10^{-3}$)	-0.27 ($4.9*10^{-3}$)
ICT Total	0.35 ($2.0*10^{-4}$)	0.49 ($5.4*10^{-8}$)
General	0.35 ($2.1*10^{-4}$)	0.42 ($4.2*10^{-6}$)
Communication	0.27 ($4.4*10^{-3}$)	0.29 ($2.4*10^{-3}$)
Process & Store	0.30 ($1.3*10^{-3}$)	0.50 ($2.5*10^{-8}$)
Generate Content	0.31 ($1.3*10^{-3}$)	0.39 ($2.9*10^{-5}$)
Safe Application	0.20 ($3.7*10^{-2}$)	0.31 ($1.1*10^{-3}$)
Solve Problems	0.27 ($4.9*10^{-3}$)	0.45 ($8.9*10^{-7}$)

Note. Grades are scaled from 1 (A) to 5 (F). Negative correlations therefore mean better grades for higher scores in self-efficacy.

covered discriminatory power of the problem coping sub-item of the self-efficacy scale, we also included this specific item in the correlation analysis. Students' perceived self-efficacy using the WIRKSCHUL scale [33] as well as the sub-item "problem coping" were found to correlate significantly with all of the analyzed factors. Both, self-efficacy and problem coping correlated with the average grade with $r_s = -0.34$ and $r_s = -0.32$ respectively. While the correlations of self-efficacy with the other factors were rather weak, several moderate correlations could be found in the problem coping sub-item: The total ICT self-concept ($r_s = 0.49$) as well as the sub-scales "general" ($r_s = 0.42$), "process and store" ($r_s = 0.50$), and "solve problems" ($r_s = 0.45$) correlated with problem coping.

These findings indicate a relevant contribution of students' self-efficacy to their overall performance. However, this effect may also work in the opposite direction: Students' self-estimated responses may be a reflection of their own grades, showing the concordance between these two factors and highlighting this as an important feature of the taken educational approach, if not even of the educational system itself.

The association between students' perceived self-efficacy and ICT competence can be seen as a result of digitalization, as acting skillfully and responsibly in a digital world seems to contribute to our perception of self-efficacy nowadays. As a consequence, digital competences are essential assets of 21st century skills in the sphere of education, which some may argue also holds true beyond education.

F. Factor Analysis

We performed an exploratory factor analysis to validate the relevance of the detected correlations. In order to interpret the relation between correlated variables, we aimed for a 3-way factor analysis, as indicated in Fig. 4 showing the corresponding scree plot. The results of the factor analysis are shown in Table V.

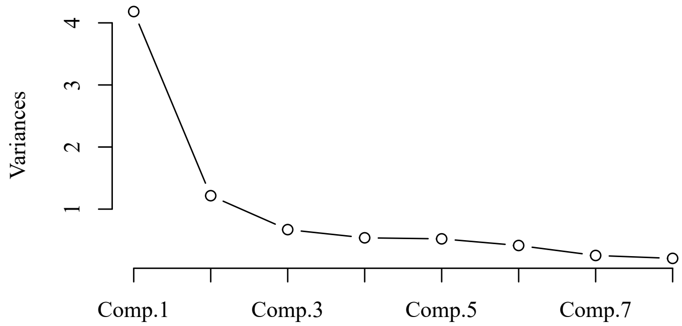


Fig. 4. Scree Plot of Factor Analysis of Students' Average Grade, Self-Perceived ICT Competence, and Self-Efficacy Using the ICT-SC25 [31] and WIRKSCHUL Scale [33]

TABLE V
FACTOR ANALYSIS OF STUDENTS' AVERAGE GRADE, SELF-PERCEIVED ICT COMPETENCE, AND SELF-EFFICACY USING THE ICT-SC25 [31] AND WIRKSCHUL SCALE [33]

Variable	**Factor 1** Perceived Information Competence	**Factor 2** General Soft Skills	**Factor 3** Perceived Success
Average Grade	0.026	-0.008	**-0.683**
ICT General	**0.468**	**0.851**	0.228
ICT Communicate	**0.554**	**0.423**	0.041
ICT Process & Store	**0.829**	0.282	0.080
ICT Generate Content	**0.856**	0.153	0.205
ICT Safe Application	**0.592**	0.299	-0.032
ICT Solve Problems	**0.682**	0.338	0.248
Self-Efficacy Total	0.253	0.199	**0.441**

Note. Loadings above 0.4 are displayed in bold.

We found that the considered aspects form 3 distinct factors, with little overlap in the less clearly distinguished variables "ICT General" and "ICT Communicate", which form their own factor of "General Soft Skills", but also partake in the ICT-related factor of "Perceived Information Competence". Unlike the univariate correlation analysis, the factor analysis does not consider self-efficacy as relevant for any of those two factors, showing a completely different aspect of students' social behavior, which goes along with average grades forming the factor of "Perceived Success".

The factor analysis shows the strong coherence of students' ICT self-concept on the ICT-SC25 [31] and highlights the strong connection between students' self-efficacy measured by the WIRKSCHUL scale [33] and their academic performance.

IV. DISCUSSION

A. Findings

Based on the introduced findings, we were able to answer our research questions the following way:

RQ1: Do learning office students still achieve equal learning outcomes compared to their peers of traditional classrooms after returning to on-campus teaching?

We were able to confirm previous findings [2], [17], [19] stating that learning office students achieve equal learning outcomes measured by the average grade after adjusting to the new way of learning, which takes one or two semesters.

Our experience showed that since the social aspects of learning are especially important in the learning office, students of this learner-centered approach suffered more during distance learning than their peers in traditional classrooms. Learning office students are used to working together and interacting with teachers on-campus, which is not as simple in distance learning. The return to on-campus teaching was therefore a relief especially for learning office students.

RQ2: To what extent are student-centered learning offices associated with students' self-perceived ICT skills and self-efficacy in comparison to traditional classrooms?

The employed research instruments provided evidence suggesting an increase in learning office students' self-perceived ICT competence, which extends previous work showing indications of an increase in students' 21st century skills in the learning office approach [12].

While we were not able to find a significant difference in students' overall self-efficacy between the two approaches, a significant increase in their self-reported problem coping ability could be found in the learning office, which is in accordance with previous work [12].

Both findings are reasonable in the light of our experience, since students work with digital tools, do project work, and solve problems independently in the learning office.

RQ3: What is the role of students' perceived self-efficacy in the interplay of academic achievement and self-perceived ICT skills?

We found students' perceived self-efficacy and problem coping ability to correlate significantly with all of the analyzed factors, including their average grade, their final grades in several subjects, as well as all the total ICT self-concept including all of its sub-scales.

An exploratory factor analysis found a model using three factors that revealed a strong connection between students' self-efficacy and their average grade.

These findings show that self-efficacy is key to be successful in school.

B. Notes and Limitations

We are aware of certain constraints limiting the generalizability of this study. First, since our study does not use random assignment, we are only able to assess statistical associations and not causality. Random assignment is neither feasible nor legally possible or ethical within the context of this study, as students cannot be forced into one of the approaches. Second, since students are able to choose between the two approaches, this study may be subject to a natural bias. Finally, being a study in the educational field, we have to work with the given sample size and the high number of additional variables that may have an influence on the results, such as students' teachers.

We want to emphasize that we took every possible precaution to protect our students' privacy and prevent any harm that could arise from participating in our study. Our students were informed that participating in the survey was completely voluntary and did not have any effect on their grading. Furthermore, we anonymized their data so that the authors did not know the identity of a response at any point after the anonymization. Finally, our students know that they participate in a school pilot project approved by the Austrian Federal Ministry of Education.

V. Conclusion

We found indications of an increase in students' self-perceived ICT skills and problem coping ability in the student-centered learning office approach, which does not happen at the cost of academic performance after initial adjustment. This adds to the evidence of student-centered learning promoting 21st century skills, once again suggesting learner-centered methods as a successful way of 21st century learning.

The discovered association between student-centered learning and an increase in self-perceived problem coping skills may stem from applied problem- and project-based learning in the learning office, while the improved ICT self-concept could be a result of the integrated use of technology-enhanced and blended learning in the learner-centered approach. However, the measured effects may also result from the person-centered attitude of learning office teachers: Carl Rogers summarized the results of a study with 296 students and found that students experiencing teachers with "high levels of empathy, congruence, and positive regard [...] Maintained or increased their scores on self-concept measures" [26, p. 207].

Students' general ICT self-concept was found to correlate with their grade in the subject "software development", suggesting that digital competences as perceived by the students themselves are essential to be successful in developing software. Furthermore, the ICT sub-scale "generate content" correlated with students' final grade in English, showing the importance of language skills in content creation. Self-efficacy and its sub-item "problem coping" were found to be tightly and significantly connected to students' grades and ICT self-concept, as found in a correlation analysis. One may argue that ICT skills are an important aspect of 21st century skills and, specifically, problem solving techniques, highlighting the need to promote them as part of basic digital education.

An exploratory factor analysis fitted a model using three factors, namely "Perceived Information Competence", "General Soft Skills", and "Perceived Success". This model confirmed the strong coherence of the ICT-SC25 scale [31], but also showed a strong link between the general ICT sub-scale and the communication sub-scale. Furthermore, the model revealed a tight connection between students' self-efficacy and their academic performance in terms of average grade.

Future work includes confirming these findings using additional methods of measuring 21st century skills, such as observation- or task-based approaches. Furthermore, the identification of "best practices" to promote students' ICT and 21st century skills on a smaller scale would be a useful addition to the literature of student-centered 21st century learning.

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