Student-Centered Classrooms in Engineering Education: Concept and Evaluation of a Learning Office for Software Development and Applied Mathematics

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***Abstract*—This Research to Practice Full Paper depicts and evaluates a school pilot project introducing student-centered classrooms for applied mathematics and software development at a higher technical secondary school. These student-centered classrooms are an alternative organizational form: If students choose to participate in the pilot project, they have non-traditional class schedules. Students can choose freely which subject they want to work on each day and visit the respective room, called "learning office". Self-explanatory learning material is available in each learning office and students work independently on exercises and projects at their own pace and level, allowing them to specialize according to their personal interests. Teachers accompany pupils as coaches who help them plan and structure.**

The evaluation showed that students choosing the student-centered form need time, about half a year, to adapt to the change of system and thus perform worse in their first attempt at exams. However, after passing the first year, there is no notable difference in software development and only a weakly significant difference in applied mathematics. The average grades and passing rate of the two approaches show no notable differences. By cooperating significantly more frequently they develop social skills and show significantly higher motivation for attending school.

***Index Terms*—learning office, person-centered learning, student-centered classrooms, engineering education**

I. Introduction

Individualization and differentiation belong to the core tasks of an educator, but are indeed a challenging responsibility. Students are individuals and therefore diverse: they have different backgrounds, learning styles, interests, learning rates, and prior experiences. This paper describes and evaluates a large-scale school pilot project at a higher technical secondary school which introduced student-centered classrooms, called learning offices, aiming to foster personalization. The Austrian schooling system provides the chance to obtain a degree equivalent to a bachelor's degree in engineering according to the national implementation of the European Qualifications Framework [1] by participating in a 5-year secondary technical school instead of a four year secondary high school after graduates gained three years of professional experience.

The underlying concept as well as the connection to person-centered learning of the learning office project are outlined in this paper. The proposed approach, which is currently being transferred to further schools due to its success, is illustrated using the examples of a software development and applied mathematics learning office.

These student-centered classrooms were introduced in 2016 and cover general knowledge subjects as well as technical subjects. The students can, with some restrictions, freely decide which area they want to work on and to what extent: if a student is more interested in software development than network technology, he or she can do only the basic exercises in network technology and visit the software development learning office more often, also solving advanced exercises and projects in software development. Using this approach, they can individually work at their own pace and choose the depth for each subject, which is also transparently reflected in the grades they receive.

This individualized approach promotes and utilizes the diversity of the students and handles different levels of prior knowledge as each individual can work at their own pace. The resulting flexibility and freedom give the students the opportunity to develop their skills based on their individual interests. Furthermore, the students improve essential social competencies by being responsible for their own learning process, such as self-reliance, self-organization, as well as their ability to learn, preparing them for working life and university.

A. Roots in Person-Centered Learning

The connection between student-centered learning offices and the work of Carl Rogers, the originator of the person-centered approach and client-centered therapy [2], is evident. Carl Rogers included examples of self-driven learning on different educational levels and in multiple domains in his book *Freedom to learn* [3]. Most notably, he shared the notes of Barbara Shiel's classroom experiment, in which she successfully changed her sixth-grade class to a completely self-directed form and allowed pupils to choose between the self-directed and traditional form. As we teach the same subjects in both the traditional as well as the learning office

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approach, we also provide students the opportunity to choose between those forms when they apply for admission. The learning contracts in Shiel's classroom experiment, which help students plan and check their progress, are comparable to the logbooks used by pupils of a learning office cohort.

Another example for self-directed learning in Rogers' book is Gay Swenson's project approach, in which she applied similar principles to a French course at a high school. She concluded that the "curriculum can be self-selected by the student, based on his or her own current interests and abilities" [3, p. 68]. Students of the learning office are also able to advance based on their interests via advanced exercises and projects. However, the basic curriculum is predefined by law and needs to be the same as the curriculum of traditional classrooms. Most subjects require students of both approaches to take centralized exams. Therefore, despite their basic freedom of choice, students of the learning office cohort have a coarse time schedule to consider.

Similar to the described experiments in Rogers' book, the self-directed form of the learning office approach also strives to meet Rogers' elements of experiential learning [3]. Including students in the learning process and supporting them as coaches promotes their *quality of personal involvement*. *Self-initiated* learning is the core concept of the learning office as they are not forced to study, but rather encouraged to do so. The learning office concept aims to be *pervasive*: the students of the learning office cohort experience a completely different style of education, allowing them to individually progress and develop essential social competencies. Learning offices make use of different methods of self-assessment, which ensures that learning is *evaluated by the learner*. Project-based exercises, which are especially planned for higher grades, aim to make the topics *meaningful* to the learners.

However, facilitating significant learning depends on more than the organizational structure: the person-centered attitude of the educator is considered even more important. Carl Rogers identified three core attitudes promoting experiential learning [2]: realness, acceptance, and empathy. Jerome Freiberg, who built on and extended Rogers' research, cited a study by the National Consortium for Humanizing Education [4], which came to the conclusion that students learn more and behave better when they experience these attitudes. Motschnig, Sedlmair, Schröder, and Möller introduced elements of person-centered learning into a human-computer interaction course attended by 200 students at university level [5]. In turn, the course was the best rated bachelor-level computer science course assessed by a cohort of at least five students.

Student-centered learning offices provide self-explanatory learning resources and use a technology-enhanced learning approach. Bauer, Derntl, Motschnig, and Tausch reviewed person-centered and promotive activities and shared their experiences of applying them in technology-enhanced environments [6]. Most notably, they stated that teachers caring for their learners provide and organize learning resources and tend to be the main personal learning resource, which also holds true for learning offices. Furthermore, they highlighted that the learning success and motivation of students can be promoted by having advanced peers available as learning resources, another synergy of the proposed learning office concept. Kyprianidou, Demetriadis, and Pombortsis developed a pedagogical model and specified a web environment based on person-centered principles to make learning more effective [7]. Their specifications resemble those of a learning office and include encouraging reflection, informing students about their strengths and weaknesses, as well as promoting the dialog with instructors and co-learners. Standl has developed a framework of educational design patterns for computer science education at secondary school level [8] with the background of person-centered learning. These patterns are iteratively evaluated for their use in the learning office, adapted, and integrated in the concept, including the self check and peer check [9], [10] as student-centered methods.

Although person-centered learning represents the core principle behind the proposed learning office concept, it is influenced by a number of educational theories and trends. The initiated cognitive and metacognitive processes can be described by models of self-regulated learning [11], while the organizational structure, self-organization, peer learning, as well as the constant and open access of learning resources resemble parts of the philosophy of open education resources [12], [13] and the cognitivist learning theory [14]. Flipped classrooms, which typically use blended learning approaches, are related concepts of the learning office: in a flipped classroom, students study new content at home in order to use the class time to clarify questions, conduct problem-solving activites and tests, or work on lab exercises [15]. Flipped classrooms have received a lot of attention lately in engineering education [16] and are also being researched in combination with elements of gamification [17]. Gamification applies game design principles to non-game environments [18], with the goal to engage users and solve problems [19], and is also an increasing market [20], [21], including the educational sector [22]. Hence, educators in the field of computer science are currently applying elements of gamification to the classroom to actively involve and engage students [23]–[27]. Some learning office subjects use a gamified approach and will be further enriched with game-based learning in the future.

B. Learning Office School Pilot Project

The idea of the learning office, derived from the German word "Lernbüro", originated from the approach of Margret Rasfeld, formerly head of the Evangelical School Berlin Centre, who introduced a similar concept at her school [28]–[30]. However, her approach includes only general knowledge subjects like German, English and mathematics [31], raising the question whether this concept can be generalized for technical subjects.

In order to evaluate the applicability of learning offices to computer science education, student-centered learning offices were introduced within the scope of a school pilot project at the Information Technology department of the Vienna Institute of Technology (TGM) [32], a higher technical secondary

school (K9-13). The learning office project was approved by the Austrian Federal Ministry of Education in 2016. Currently, the ninth grade, which started in 2017, and the tenth grade, which started 2016, have two traditional cohorts and two learning office cohorts each. The eleventh, twelfth, and thirteenth grades are to follow as the students complete each year.

In general, a learning office, also called learning atelier, is characterized by the following criteria: [10], [31], [33]:

- Students work independently on self-explanatory learning material split into well-defined learning modules
- Students work at their own pace and level
- Students are required to plan, carry out, and evaluate their own learning plans, allowing them to choose time and depth for each subject
- Educators not only provide their expertise, but also assist students in planning, structuring, and reflecting their learning as coaches or tutors
- Students are assisted in structuring the content via regular coaching sessions, logbooks, and learning paths
- The learning office encompasses different subjects and makes use of different social forms
- Due to the focused learning atmosphere and the fact that students always know what to do, the teacher has time to individually coach them
- After students have completed a learning module, they register for an exam to receive a certificate and feedback for their future work
- Teachers are team players, design the learning atmosphere, prepare material, and discuss the individual progress of the students

To enable students this freedom of choice, the class schedule of the students of the learning office was modified to be shaped less strictly. Table I exemplifies the schedule of a learning office cohort. The "LO GK" lessons cover the general knowledge subjects German, English, and applied mathematics, while "LO TS" includes the technical subjects software development, system engineering, media technology, and network technology. "LO C" lessons are additional coaching hours in which students see a teacher and discuss their progress and future plans. Natural sciences, gymnastics, history and political education, religious education, as well as computer practice lab are taught in a traditional way due to administrative constraints.

During learning office hours, students are able to choose the respective learning office they want to visit on the current day. Therefore, in the morning students may choose between German, English, and applied mathematics, while in the afternoon they may select software development, system engineering, media technology, or network technology. Synergies develop as soon as classes of multiple grades use the learning office concept. The time slots of the learning offices in the class schedule are partly the same in multiple classes and grades, which means that students of multiple grades share the same learning office rooms at the same time. This promotes peer teaching: learners in lower grades are able to ask students of higher grades for help and advanced students of the same grade help their peers.

Table I
LEARNING OFFICE COHORT CLASS SCHEDULE EXAMPLE

Day	Lesson								
	1	2	3	4	5	6	7	8	9
M	LO GK	LO GK	LO GK	NSC	NSC		LO TS	LO TS	LO TS
T	LO GK	LO GK	GYM	GYM		HP	LO TS	LO TS	LO TS
W	LO GK	LO GK	LO C	REL		HP	LO TS	LO TS	LO TS
Th	LO GK	LO GK	LO C	REL	NSC				
F	CO	CO	CO	CO					

LO GK	Learning office for general knowledge subjects
LO TS	Learning office for technical subjects
LO C	Learning office for coaching and soft skills
NSC	Natural sciences
GYM	Gymnastics
HP	History and political education
REL	Religious education
CO	Computer practice lab

The basic setup of our learning office project has been partly described in [10], [31], yet an evaluation of our research was still to be done. This paper presents the results of our research of the first one and a half years. The proposed concept of these student-centered classrooms are illustrated and evaluated with two courses in the grades 9 and 10: an applied mathematics course and a software development course. The course structures and modules are outlined and an evaluation of our first iteration with two cohorts is presented. The research questions to answer are:

1) Are there any differences in the performance of students of the learning office project compared to traditional classrooms in the subjects software development and applied mathematics?
2) Does the learning office approach influence the overall advancement rate of students?
3) What additional value does the learning office approach provide to the learners?

This paper is structured as follows. The following section presents the chosen research methods, while section three and four introduce the concepts and evaluations of the applied mathematics learning office and the software development learning office respectively. The fifth section presents the results of our overall evaluation of the learning office project. Section six discusses the findings as well as the validity and research ethics. The seventh section concludes the paper and outlines options for future work.

II. RESEARCH METHODS

The overall research framework of the long-term learning office project uses a combination of an observational study design and elements of a quasi-experiment with a control group. As students and their parents choose between the

traditional and learning office approach, we have no influence on the assignment of the groups and simply observe the outcome, which is characteristic for observational studies [34]. Quasi-experiments also use a non-randomized setup and are used when random assignment is not feasible or ethical [35], yet an experimental study allows investigators to intervene and influence the variables [34]. In our case, we design the centralized exams to be taken by both groups.

To address our research questions, the following data of four and eight cohorts respectively were analyzed within this study in addition to our observations and dialog with our students:

Centralized exams: All students of grade 9 and 10 take identical written exams at the same time, which are required due to the obligatory curriculum. In this way, the student-centered form can be compared to traditional classrooms regarding the learning outcome. If students do not pass an exam, they have the possibility to take an additional oral exam to compensate the negative grade. We surveyed and analyzed the exam results of all eight cohorts of the current school year 2017/18 in the subjects software development and applied mathematics.

Average Grade: To evaluate the overall performance of students of both organizational structures, the average of the final grades on all subjects upon completion of the school year of the four cohorts of 2016/17 were evaluated and compared.

Advancement rate: In order to complete a grade and advance to the next, the students have to pass all subjects upon completion of a school year. If a student did not pass one or two subjects, he or she has the possibility to take an extra "advancement exam" after the summer break. If he or she does not pass the advancement exam, the grade may be repeated. The overall advancement rate after the summer break was collected and compared between both approaches.

Survey: We conducted a survey amongst our students of grade 9 and 10, asking for their level of agreement on various aspects of their social and learning environment on a five-point Likert scale. Specifically, we asked our students whether they like to go to school and if they cooperate in their studies.

III. Case Studies

A. Applied Mathematics Learning Office

1) Description: Applied mathematics was structured into modules which are implemented as printed booklets providing explanations and exercises described in detail for the students. These learning resources are the basis for creating their personal written booklets with mathematical definitions, graphics, descriptions, and exercises solved by the student and checked by the instructor. In addition to the hard-copy version of the booklets, the learners are provided with online material in the form of a module-based Moodle courses. Complementing the booklets, the online courses provide videos created by their teachers which guide students through the examples in their booklets. Online exercises allow them to evaluate their individual learning advancement using randomized tests with a pool of questions for each module. The online self-checks provide immediate feedback to the learners without the fear of failing in front their peers or teachers. They also allow students to check whether they are ready for the in-class tests, which are additional assessments to the centralized exams.

All hand-written work by the student as well as in-class evaluations are checked by the teacher, who gives immediate personal and individual feedback. As different teachers are in the learning office on different days of the week, the students have the chance to receive different explanations and feedback from different persons.

The learning office is designed to enable peer learning: students of a higher grade or more advanced students may tutor others. Our evaluations and in-class observations indicate that this is the case: a survey among students of the traditional and learning office approach showed that students of the learning office are more likely to work together. The long-term concept involves implementing peer review as a method of student-centered learning, which we described in [10]. Students may check the solutions of each other before showing them to the teacher to help them learn from each other and find mistakes.

The students of the learning office tend to be more self-reliant and organized than their peers as this is the basic success criterion of the learning office. This trend can be seen in the following evaluations: we observed that students adapt to this concept within about half a year, which is also the approximate time of students who chose the traditional approach to get used to the new school, measured by their performance in the subject applied mathematics.

2) Evaluation: In the subject applied mathematics, students' learning outcome can be compared by synchronized standardized exams: all students of the same grade take the same exam at the same time. Thus, we can compare the actual distribution of grades and the 'average' grade measured by the sample median between students of the learning office and traditional approach. In the first grade, we observe a notable difference between students of the learning office and students in a traditional setting. At the first and second standardized exam in applied mathematics, we noted that being a student of the learning office changed the distribution of grades significantly at the 5%-level, tested by chi-squared test of homogeneity resulting in p-values of 0.0123 and 0.0219 respectively. Given the low sample size and resulting low power of the tests, finding significance with a non-parametric test of lower power than a parametric test provides evidence that the distributions are actually different in spite of rather large p-values. Also, a Wilcoxon rank sum test for shift in location of the 'average' grade measured by the median showed a highly significant difference in average grades with p-values of 0.0004 and 0.0014 respectively.

However, during the school year students are likely to adapt to the learning office system. At the third exam in applied mathematics, a chi-squared test cannot find any evidence for a change of grade distributions between learning office and traditional approach anymore with a p-value of 0.2515. Yet, there still remains a slight shift in average grades between learning office and traditional setting, found weakly significant by the Wilcoxon rank sum test with a p-value of 0.0314.

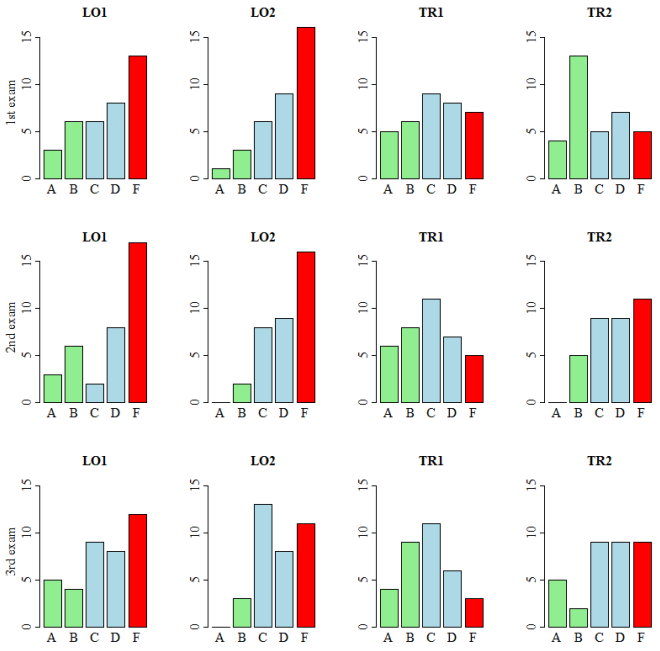

Figure 1. Bar charts of the distributions of grades of all learning office (LO) and traditional (TR) cohorts on the centralized exams in the subject applied mathematics

The development of the grade distributions in applied mathematics is visualized in Fig. 1 and the absolute numbers are displayed in Table II. The first row of graphs in the figure presents the results of the first centralized exam of both approaches. The results of the second and third exam are shown in the second and third row. While the differences on the first two exams seem to be strong, a more similar distribution can be observed at the third exam. However, this graph only presents the results of the first attempt: students still have the possibility to compensate a negative grade with an oral exam.

These findings indicate that students struggle at the beginning with adapting to the new and different learning atmosphere and require approximately one semester to get used to the new system. From then on, they do not perform systematically worse than the students of the traditional approach: the differences in the grade distribution disappear mostly, yet not completely. Depending on the module, Wilcoxon rank sum tests show weakly significant differences between the 'average' grades in learning office versus the traditional approach with the grades being shifted slightly to the 'worse' for the learning office.

A possible explanation for this is that each module material is split into "basic" and "advanced" competencies, which are marked explicitly for the students of the learning office. They know that they only have to fulfill the basic competencies in order to pass the course. On the other hand, students of the traditional approach are presented all basic and advanced competences and receive no pre-selection of which material is important. This might result in them being able to deal with a

Table II
GRADES OF LEARNING OFFICE (LO) AND TRADITIONAL (TR) COHORTS ON THE CENTRALIZED EXAMS IN THE SUBJECT APPLIED MATHEMATICS

Form	Exam	Exam Grade Frequency				
		A	*B*	*C*	*D*	*F*
LO1	1	3	6	6	8	13
LO2	1	1	3	6	9	16
TR1	1	5	6	9	8	7
TR2	1	4	13	5	7	5
LO1	2	3	6	2	8	17
LO2	2	0	2	8	9	16
TR1	2	6	8	11	7	5
TR2	2	0	5	9	9	11
LO1	3	5	4	9	8	12
LO2	3	0	3	13	8	11
TR1	3	4	9	11	6	3
TR2	3	5	2	9	9	9

wider variety of materials than students of the learning office, who may aim only for the basic requirements as they specialize in other subjects according to their interests. Therefore, this seems like an obvious effect: the basic concept of the learning office allows students to specialize in the first place. To find out whether students actually use this advantage to focus on other subject, we analyzed the average grade of students upon completion of the year, which is presented in the fifth chapter.

B. Software Development Learning Office

1) Description: At our department, software development encompasses learning basic programming concepts by the means of Java in grade 9 and 10. Thus, the software development learning office covers concepts like variables, loops, structured programming, and object-orientated programming. The course itself was structured in modules in accordance to the centralized exams so that each exam encompasses the material of one module. Within a module, the subject matter was subdivided into smaller units. All learning resources for the modules and units are available online on the elearning platform Moodle. For every unit, the students have the following learning resources and tasks on the platform:

- a script covering the subject matter, which the learners either print out or study online
- a worksheet asking the learner questions about the presented material in the script
- several practical programming assignments covering the basic competencies
- several practical programming assingments covering advanced topics for the material in the selected unit

In addition, every student is asked to transform the knowledge he or she gained into a graf-iz, a tool which enables the learner to summarize the material into a graphical representation accompanied by notes covering the central concepts on one page [36].

The written materials produced by the learners (i.e. the worksheets and the graf-iz pages) are presented to and discussed with the teacher, who also grades their work. The same procedure is utilized for programming assignments covering the key aspects. As soon as the learners have completed these

Table III
FIVE NUMBER SUMMARY PLUS MEANS OF AVERAGE GRADES IN LEARNING OFFICE (LO) AND TRADITIONAL (TR) APPROACH

Form	Min.	$Q_{25\%}$	Median	Mean	$Q_{75\%}$	Max.
TR	1.00	2.16	3.00	2.78	3.41	4.55
LO	1.27	2.41	2.91	2.935	3.45	4.62

tasks, he or she is able to advance to next unit. This rule ensures that no errors in concept and application are carried on from one unit to the next.

All other programming assignments are graded online every two or three weeks. These grades do not block the advancement across units. Nonetheless, the learners are encouraged to correct their programs as the individual grades on these assignments influence the final grade of the learners.

2) Evaluation: In software development, we compared the learning outcome of three out of four cohorts with standardized exams. The fourth traditional cohort took separate exams and thus is not included in our analyses. To date, the third exam is about to be graded and therefore only the first two exams are included in this evaluation.

Our findings in software development match the findings of the applied mathematics learning office. At the first of the first two exams, the students struggle severely with the new learning office responsibility in addition to the new subject software development, which they are taught for the first time in their school career. At the first and second standardized exam in software development in the first grade, a chi-squared test of homogeneity showed that the distributions of grades between learning office and traditional approach differ significantly at the 5%-level with p-values of 0.0049 and 0.0080 respectively, while the shape of distributions is similar to applied mathematics exam grades visualized in Fig. 1. Also, a Wilcoxon rank sum test for shift in location of the 'average' grade measured by the median showed a highly significant difference in average grades with p-values of 0.0005 and 0.0007 respectively.

However, in the second grade, the difference in the distribution of grades tested by the chi-squared test disappeared completely with a p-value of 0.5166 and 0.8237 respectively. Also, unlike in the applied mathematics learning office, no shift in the average grade was found in software development, showed by a Wilcoxon rank sum test with p-values of 0.7525 and 0.8452 respectively.

C. Overall Evaluation of Performance in the Learning Office

To evaluate whether students of the learning office perform differently in general, we analyzed the average grade across all subjects. In the Austrian school system, it is common to calculate the arithmetic mean of grades over all subjects at the end of the school year with 1 equaling the best grade A and 5 equaling the worst grade F. With a Wilcoxon rank sum test, we tested the difference between the students' overall performance of the learning office and the traditional approach, finding no significant difference in their average grades at the end of their first year with a p-value of 0.3858. However, we can observe that the distribution of average grades is different for the learning office and the traditional approach. Most notably, we find that the learning office students' grade have a symmetric distribution around the median of 2.91, whereas the traditional learning students' grade distribution is shifted towards a slightly worse median of 3, while the distribution is skewed toward better grades, as is shown in Fig. 2 and Table III.

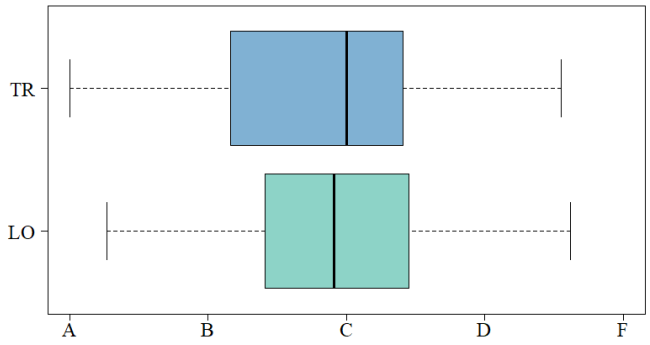

Figure 2. Box plot of the distributions of average grades in learning office (LO) and traditional (TR) approach

As a central metric in education is the dropout rate of students, we compared the overall rate of students who were eligible to advance to the next grade at the end of the school year, which gives another holistic overview of the overall learning outcome of students. For this matter, the "advancement exams" after the summer break have to be taken into account.

Overall, ten students of the two learning office cohorts were allowed to take the advancement exam for one or two subjects they did not pass in the school year of 2016/17 in order to advance to the next grade. Out of these ten students, three had to pass two subjects, seven had to pass only one subject. In the traditional setting, twelve students were allowed to take the exam. Three of them had to pass two subjects, while nine of them had to pass the exam for only one subject.

Three of the learning office students chose to repeat the lower grade by their own choice without trying the exam – two of them would have had to pass the exam for two subjects. All the other seven out of ten learning office students passed the exams and were allowed to advance to the next grade.

Contrary to this, only five out of all twelve students of the traditional approach who tried the exams passed them, three in one and two in two subjects respectively. The other seven out of twelve students tried the exams, but did not pass. Not a single students chose to repeat the year by his or her own choice. Table IV shows the overall advancement frequencies of the students of the learning office and traditional approach. We observed that overall, 43 of 68 (63%) students of the learning office versus 38 of 66 (58%) students of the traditional

Table IV
ADVANCEMENT RATE OF LEARNING OFFICE (LO) AND TRADITIONAL (TR) CLASSES

	Traditional	Learning Office
All subjects passed	33	36
Advancement exam successful	5	7
Waiver of advancement exam	0	3
Advancement exam failed	7	0
More than three failed subjects	21	22

approach advanced to the next grade.

Furthermore, we conducted a survey amongst all 247 students of grade 9 and 10 with 205 respondents. The survey revealed that students of the learning office tend to cooperate with their peers more frequently, found with a Kruskal-Wallis test with a p value of 0.0209 for grade 9 and a p value of 0.0020 for grade 10. This suggests that students of the learning office gain their knowledge and performance from cooperative learning more frequently, implying superior social competencies. Additionally, we found that students of the learning office in tenth grade stated that they like going to school more than their peers of the traditional approach. This difference was found to be significant with a Kruskal-Wallis test with a p-value of 0.0375. This shows a higher intrinsic motivation for learning and working together with their peers.

IV. DISCUSSION

A. Interpretation of Findings

We found that the students of the learning office seem to struggle with the change of system at the beginning, which is shown in the grades on the first centralized exams in applied mathematics and software development in their first year. However, the distribution of the grades become more alike as the students progress, up to the point where statistical tests return no significant results in software development and only weakly significant results in applied mathematics.

A notable change in the distribution of grades at the centralized exams is a natural consequence of the learning office approach as students are given the freedom to specialize based on their individual interests and progress according to their individual learning rate. If the average of all grades upon completion of the first year is analyzed, the learning office performs equally compared to the traditional approach with a median average grade of 2.91 (learning office) compared to 3 (traditional). Hence, students appear to specialize in other subjects than applied mathematics or just take more time to understand it, resulting in a negative grade on the centralized exam, but compensating it later. Specializing and progressing at their own pace is indeed one of the main intentions of the learning office approach. Furthermore, the average grade distribution of the learning office was found to be symmetric, while the traditional approach produces a skewed distribution towards better grades. On the one hand, the symmetric distribution could be a hint for fair and transparent rating criteria, allowing most students to focus on the basic competencies which are awarded with a C. On the other hand, it could be an indicator that the requirements for an A and B are higher in a learning office than in a traditional setting.

The overall rate of students eligible to advance to the next grade was found to be higher in the learning office: while 63% of the 68 learning office students passed, 58% of the 66 students in the traditional setting were eligible to advance. Every learning office student who took the advancement exam after the summer break passed, while seven out of twelve students of the traditional approach did not pass. This indicates that the students of the learning office are more capable of studying on their own over the summer break, suggesting that they were able to acquire the required self-reliance to work independently. Three learning office students chose to repeat the school year by their own choice, which is an indicator that learning office students are more self-aware and able to self-assess their own level of knowledge.

To sum up, we found the following answers to our research questions:

1) Are there any differences in the performance of students of the learning office project compared to traditional classrooms in the subjects software development and applied mathematics?

We found that students who choose the learning office approach take more time to get used to the new system than students choosing the traditional approach in the subjects applied mathematics and software development. However, as the students progress, these differences become smaller, leading to equal results in software development in the second year and only weakly significant differences in applied mathematics. Across all subjects, measured by the average of all grades, the performance of students seems to be equal.

2) Does the learning office approach influence the overall advancement rate of students?

No, we found no evidence that the learning office approach has an effect on the rate of students who are eligible to advance to the next grade. The advancement rate of the students of the learning office was slightly higher than in the traditional approach.

3) What additional value does the learning office approach provide to the learners?

As the overall performance of students did not change notably, we observed that the students of the learning office additionally benefit from the social competencies they acquire. The learning office requires a high amount of self-reliance, self-organization, independence, self-awareness, intrinsic motivation, self-assessment, and ambition – students are not "forced" to learn, but rather encouraged. We found that students of the learning office show an increased motivation to go to school. Consequentially, we observed that the students of the learning office approach like to work together with their peers more than students of the traditional approach, which further promotes their communication competencies and strengthens their interpersonal relationships. An additional indication for these acquired social competencies can be found in our advancement statistics: every student of the learning

office who chose to take the advancement exam passed it, while some students showed self-awareness by choosing to repeat the school year by their own choice.

B. Notes on Validity and Research Ethics

Despite the quality of the presented data, we are aware of the limitations of this observational study. First, having no control over the assignment of our students to the traditional and learning office approach introduces a natural bias. Random assignment is neither feasible nor possible in this case as we need the parents' agreement to take part in the school pilot project. Second, the small sample size of about 25-30 students per cohort limits the generalizability of this study – a common issue of research in the educational field. Third, the results may depend on more than the discussed variables: it is not feasible to enforce the same environment, like class teachers, for all cohorts. Finally, being a study in the educational field, we are humans working with humans. Every cohort is unique and different as people are individuals, which is why the same concept may yield different results with different people.

We took several precautions to protect our students from any drawbacks by taking part in our learning office project. The evaluations for this study were solely conducted by instructors who do not teach or grade them. The data were anonymized and aggregated to protect the identity of our students. Finally, students and their parents who choose to take part in the school pilot project know that they take part in a study which evaluates the effectiveness of the learning office.

V. Conclusion

This paper presented our school pilot project "learning office" introducing student-centered classrooms which allow students – with some constraints – to specialize and work at their own pace. The class schedule of students of the learning office was modified to allow them to choose between general knowledge subjects and technical subjects within given time slots. They decide on their own when they want to study which subject and topic.

The connection to person-centered learning is evident: self-driven approaches were described thoroughly by Carl Rogers, yet only a few schools use this kind of concept in Austria. The learning office is based on the concept of Margret Rasfeld. However, she only used this concept for general knowledge subjects, which is why the application to technical subjects is an innovation. Learning offices can be compared to flipped classrooms, in which students also study new content by themselves and spend the in-class time to discuss the content and do exercises.

Our evaluations showed that students of the learning office experience some troubles with the change of system at first, but get used to this concept after about one semester. In their second year, students of the learning office performed equally on the centralized exams in the subject software development, while there is still a weakly significant difference in applied mathematics. However, the distribution of the average grades upon the completion of the first year showed no notable differences between the two approaches. The same applies to the rate of students eligible to advance to the next grade.

Future work includes collecting more qualitative data to complement our evaluations via interviews and surveys. Furthermore, analyzing and comparing more subjects in the learning office setting will provide additional information on how students develop besides computational and logical competencies. As the learning office project will be extended by another grade every year until it encompasses K9-K13, future work also includes evaluating higher grades in similar study settings.

Overall, we believe that our students benefit from the learning office approach in terms of acquiring additional social competencies: being responsible for one's own learning process requires a high amount of self-reliance, self-organization, independence, and self-awareness. This may also be the reason students need about one semester to get used to this approach as they need to acquire these competencies first. However, above all, it gives student valuable freedom and helps them to individually develop according to their own interests as human beings.

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