Formation of Study Groups: Exploring Students' Needs and Practical Challenges

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Abstract: Learning in study groups offers students the opportunity to exchange ideas about lecture content, discuss questions, and network with others. However, little is known about how self-organised study groups (i. e., study groups that are organised and managed by students themselves) should ideally be composed to meet students' needs. Following previous studies on group composition in collaborative learning, a requirement analysis was carried out, consisting of a focus group and an online survey. Three factors were identified as being particularly important to students: A similar level of conscientiousness, a similar attitude towards reliable attendance at meetings, and a similar preference for online meetings. Based on these results, a tool was implemented that uses a genetic algorithm for group formation. This prototype was tested and evaluated in a field study in two university courses. The field study suggests that there is a general interest in using such a tool. However, it seems to be a challenge for many students to establish contact and meet with the other members of the proposed study group. Possible reasons and solutions to this problem are discussed.

1 MOTIVATION

Working and interacting together in groups is associated with many benefits, ranging from academic advantages to positive social and psychological effects (Laal and Ghodsi, 2012). For this reason, collaborative learning methods, such as group work, are often used in universities and colleges (Davidson et al., 2014).

In addition to the mandatory group work, which is an integral part of many courses, students also have the opportunity to join self-organised study groups. Participation in such study groups is not obligatory and the concrete design of the learning process is left to the students themselves. Compared to mandatory group work, there has been relatively little research on these self-organised study groups. However, a better understanding of them could help to support students in their learning and promote networking among students. This is particularly relevant in the context of mass education, i. e., in courses that are attended by several hundred students.

These types of courses require high self-regulatory skills as the exchange between the lecturer and the students as well as the exchange among the students is often limited (Strickroth and Bry, 2022). Thus, these courses in particular do not initially offer the opportunity for in-depth exchanges with others and it is therefore up to the students themselves to find other fellow students for the purpose of learning together. One of the main issues in this regard, is to find the "right" persons to study and possibly start a study group with. It cannot be assumed that the students know all their fellow students well enough to know which persons they study well with or not. Hence, the use of technology for the group formation seems essential to help individuals find the best study group for them.

This paper aims to contribute to a better understanding of study groups in order to provide initial indications of how a tool for forming study groups should be designed. The aspect of the group composition of study groups is examined in particular. The appropriate composition of study groups is very important for students in general (Rybczynski and Schussler, 2011). However, no systematic investigation has yet been carried out with regard to the factors that are particularly relevant from the perspective of the students themselves. Considering the students' perspective is important though, in order to gain valuable insights into their experiences and to better identify how to

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support their learning (Cook-Sather, 2002). Presumably, the students' perspective is particularly relevant regarding the context of study groups: Firstly, because it is a learning experience that is not externally influenced (e. g., by teachers or instructors), but only by the students themselves. Therefore, students themselves can probably best assess the factors that enhance or hinder this experience. Secondly, because the participation in these self-organised study groups is voluntary. Dissatisfied students, whose expectations are unmet, can easily leave their study group. To prevent this, it is crucial to ensure that students' expectations are fulfilled.

Therefore, the present work pursued two goals: The first step was to carry out a systematic requirement analysis with students in order to identify factors which are according to students most important for the formation of self-organised study groups. On this basis, a prototype was developed for a tool that students can use to find a study group. In a second step, the prototype was tested in the field in two introductory Bachelor's courses (computer science and math) to determine how well the study groups formed by the prototype worked and what difficulties and challenges arose.

In summary, this paper addresses the following two research questions:

- What are relevant factors for the composition of study groups from the students' point of view?
- What possible challenges need to be considered when using a tool to form study groups?

This paper is structured as follows: Section 2 provides an overview of the previous research literature on the composition of student groups. Section 3 describes how the first research question was addressed, presenting methods and results. Based on these findings, a prototype for a tool for the formation of study groups is introduced in Section 4. Section 5 presents the field evaluation of the tool. The results of the studies are discussed in Section 6. Finally, the paper closes with conclusions and an outlook.

2 RELATED RESEARCH

Students working together in groups is generally referred to as the concept of collaborative or cooperative learning: Both of these terms describe a pedagogical approach which is characterized by two or more people interacting with each other to achieve a common goal (Dillenbourg, 1999; Gillies, 2016). It should be noted that there has been debate about the exact distinction between these two related concepts (Jacobs, 2015; Panitz, 1999). For the present work, we follow the distinction made by Panitz who refers to collaborative learning as a broader concept or philosophy that requires group members to build a consensus by interacting with each other and is more student-centered than cooperative learning which is a form of cooperation that is closely controlled by a teacher (Panitz, 1999). According to this view, study groups can be seen as a form of collaborative learning. This is consistent with previous research literature which also refers to learning in study groups as self-organised collaborative learning, a form of learning that takes place without external guidance but is instead mainly driven by the initiative of the learners (Melzner et al., 2020). When collaborative learning methods are combined with learning technologies, e. g., to connect students or facilitate resource sharing, it is also referred to as computer-supported collaborative learning, abbreviated CSCL (Dillenbourg and Fischer, 2007).

Although study groups should be distinguished from mandatory group work, it is still useful to examine studies regarding mandatory group work as well when examining possible factors for group formation. They provide a comprehensive overview of various factors that have already been used in this context for the composition of student groups and could also be relevant for study groups. For this reason, results relating to the context of mandatory group work will be discussed first.

Several studies have already addressed the issue of appropriate group composition, partly in connection with possible algorithms that can be used for group formation (Cruz and Isotani, 2014; Odo et al., 2019; Konert et al., 2014). Konert et al. distinguish between *person-related* and *group-related* factors: While person-related factors describe the individuals of the group (e. g., their personality traits, their level of knowledge or sociodemographic variables), group-related factors refer to the group as a whole (Konert et al., 2014). A group-related factor that has often been mentioned in the research literature is the group size which is assumed to influence group productivity (Shaw, 2013) and students' motivation (Zhan et al., 2022). Recommendations regarding group size suggest small groups, as the productivity of the individual person decreases in larger groups (Odo et al., 2019). With regard to person-related factors, there is the additional question of whether the group as a whole should be homogeneous or heterogeneous concerning these factors. Previous literature contains arguments in favour of both homogeneous and heterogeneous groups: While it has been argued that group heterogeneity may promote improved peer interactions (Magnisalis et al., 2011) and overall creativity (Nijstad

and De Dreu, 2002), it has also been indicated that trust may be higher in homogeneous groups and that this may positively influence performance outcomes (Ennen et al., 2015). It should, however, be noted that homogeneous group formation may also lead to unfairness when groups are very different from each other which may lead to some persons benefiting more from group work than others. Considering this is particularly relevant if the grouping criterion is related to the level of knowledge or performance as it has been shown that low ability students benefit more in heterogeneous groups than in homogeneous groups (Wang, 2013).

The use of algorithms is an effective way to carry out automatic optimisation with regard to the chosen factors for group formation. The most commonly used algorithms for group formation in studies on CSCL are probabilistic algorithms, such as genetic algorithms (Cruz and Isotani, 2014).

It is not clear to what extent the factors for group formation mentioned before also play a role in the particular context of voluntary, self-organised study groups, where students have a higher responsibility in terms of organising the group or dealing with various problems that may occur (Melzner et al., 2020). So far, there is little evidence of how students perceive the optimal group composition of study groups. A study by Rybczynski and Schussler examined study groups in an introductory biology course and investigated students' preconceptions via a survey (Rybczynski and Schussler, 2011). Using an open-ended question, students were asked for any general comments on study groups. One of the recurrent identified themes is the high importance of group composition, which according to the students influences factors such as usefulness, effectiveness, and productivity of the group. Overall, the students in that study mentioned that the level of knowledge of the other group members and the willingness to participate were important factors for them as well as the group size; interestingly, however, the authors point out that students generally seem to have different ideas about what makes a good group member and whether they prefer to learn with friends or strangers (Rybczynski and Schussler, 2011).

A more recent study also emphasizes the importance of a homogeneous problem perception within the group which is characterised by a shared understanding about the presence and nature of problems (Melzner et al., 2020). However, there are no clear recommendations mentioned on *how* the groups should be composed so that students perceive them as effective and feel able to tackle problems in a meaningful way.

These findings underline the importance of group composition for students and already point to individual factors that could be important in group formation. However, no systematic survey has yet been conducted that covers a larger number of the person-related or group-related factors that have already been used in the context of mandatory group work, and analyses their significance in the context of voluntary study groups. This paper aims to provide a more complete picture of how students view the factors used in previous work and what students' needs are in terms of study groups.

3 REQUIREMENT ANALYSIS FOR SELECTING GROUPING CRITERIA

Probably the most important aspect of forming groups is the grouping criteria. This section explores possible factors based on students' needs and wishes and describes the analyses that were conducted to determine which factors may be most important according to students.

3.1 Method

To explore which factors students perceive as particularly relevant, a focus group was held as a first step. Focus groups are similar to group interviews in that they are an organised discussion with a group of individuals to gain insights regarding a collective opinion; however, focus groups are more interactive since the group members do not just answer the interviewers question but are also encouraged to discuss these questions and raise new points within the discussion (Gibbs, 2012).

Regarding the present study, the focus group was held to get a more general overview on which factors students consider important in the context of study groups. The participants of the focus group should thus be able to not only express their opinions on previously used factors for group formation but also contribute their own ideas based on their past experiences with learning in study groups. Based on this general picture, the factors mentioned in the focus group were then evaluated with a larger sample in a follow-up online survey as a second step.

The focus group was held at LMU Munich university in Germany via the Zoom video conferencing tool in January 2022. Based on the recommendations by Benighaus and Benighaus, a guideline was developed prior to this (Benighaus and Benighaus, 2012).[1] In

[1]The complete guideline can be found in (Schenk, 2022).

particular, the guideline included a section containing questions about different factors for group composition. Analogous to the categorisation made in previous research literature (Konert et al., 2014), the guideline differentiated between person-related and group-related factors. Students were presented with examples for these factors that were obtained from the previous reviews on the composition of groups in the context of mandatory group work (Konert et al., 2014; Odo et al., 2019; Cruz and Isotani, 2014) and they were asked for their opinion on the importance of these factors for the formation of voluntary study groups. Students could also name other factors important to them and discuss their significance for group formation. In addition, the guideline contained questions about general expectations that students have regarding a tool for forming study groups, e. g., how much time the usage of the tool should take.

Six students from the fields of computer science, physics, media informatics, psychology, and school psychology were recruited via personal contact and participated in the focus group. The age of the students ranged from 21 to 31 years. All participants stated that they already had experience with study groups. The session of the focus group lasted for about two hours and was recorded.

To analyse the discussion, an inductive categorisation analysis was conducted (Mayring, 2012). This is a systematic method for analysing and structuring qualitative data by incrementally developing a system of categories from the data material. The categories are formulated as terms or concepts that are then being used to assign relevant text passages to the respective category. Thus, the resulting categories represent umbrella terms that summarise the content of the discussion (Mayring, 2012).

Based on the categories developed using this method, it was specified in more detail which factors may play an important role in the formation of study groups from the students' point of view. While the categories refer to general topics of the focus group, the factors represent concrete examples that the students had mentioned as possibly important factors for group formation in this context.

Based on the factors identified this way, an online survey was conducted via the SoSci Survey web application.[2] The aim of this survey was to prioritise the factors to decide which factors should be taken into account by an algorithm for group formation. Thus, it should be determined which factors are *most* important from the students' point of view. The aim was not to identify new factors. However, students had the opportunity to comment on the study (and thus, also on possibly missing factors).

In order to be able to do a prioritisation and select only the most important factors for group formation, items were designed to indicate that a particular factor is of high importance for study groups (e. g., for the factor "Preference for Online Meetings": "For study groups in general, it is important that people in the group have the same preference regarding the type of meeting (online vs. face-to-face)."). These items could be rated on a 5-point Likert scale (1=strongly disagree, 3=neither agree nor disagree, 5=strongly agree). To further motivate respondents to decide which factors were most important to them in relation to the other factors, at the end of the questionnaire the students were asked to select a maximum of three factors that they considered most important. This way, it was possible to determine the importance of the factors through two different measurements: On the one hand, the degree of agreement with a statement. This value was then averaged over all respondents. On the other hand, the frequency with which a statement was mentioned as one of the most important factors overall. In addition to these prioritisation items, the questionnaire included questions about demographic characteristics as well as personality traits such as extraversion, conscientiousness, and perseverance. For the measurement of extraversion and conscientiousness, the respective items from the 30-item short version of the NEO Five-Factor Inventory were used (Körner et al., 2008), furthermore the six items of the scale "Perseverance" were taken from the 12-item Grit Scale (Fleckenstein et al., 2014).[3]

The online survey was carried out in February and March 2022 and lasted 18 days. It was advertised via various email distribution lists at four German universities and was open to students from all disciplines. The data was analysed from all respondents who indicated that they are older than 18 years and accepted the privacy agreement. The final data set consists of 160 students (69 male, 87 female, 4 diverse) and was analysed using the software R. The average age of the respondents was 25 years (SD = 7.71, [18, 63]). In total, students from 37 different fields of study took part, with computer science and media informatics being the most common subjects.

3.2 Results

The results of the focus group are briefly presented first, as they form the basis of the online survey. The topics discussed in the focus group could be divided into the

[2]https://www.soscisurvey.de/, last accessed: 2023-11-22

[3]The complete online questionnaire can be found in (Schenk, 2022).

following ten categories, using inductive categorisation analysis: "Interaction with Others", "Common Goals", "Personality Traits", "Organisation of Study Groups", "Attitude towards Reliability", "Knowledge and Skills", "Sociodemographic Criteria", "Consideration of Health Limits" (e. g., acknowledging that one also needs breaks and taking them consistently), "Group Size", and "General Requirements for a Tool for the Formation of Study Groups".

Major themes in the focus group concerned reasons why students join study groups and the resulting expectations regarding study groups. On the one hand, the social component of study groups (i. e., the interaction with others) can be very important for some students and may be one of the main reasons why they decide to join a study group. On the other hand, the participants of the focus group stated that interaction with others can also be perceived as distracting and not being conducive to their learning experience. It was suggested by the participants of the focus group that certain factors, such as personality traits, may be more important for those students who join study groups mainly for social reasons.

In general, the participants of the focus group discussed the possibility that students have different learning goals when it comes to learning in study groups: For some students it might be a matter of (fully) understanding the material while for others it might be just a matter of passing an exam. The participants of the focus group therefore assumed that depending on the learning goals, the level of commitment also varies and that this may be why different learning goals could probably have a negative impact on group dynamics.

The general organisation of study groups was also discussed in the focus group. As mentioned before, students have to take care of the organisation of study groups themselves and can make different decisions on this issue: For example, it is not specified that study groups must meet in person. In fact, one focus group participant said that she preferred learning in online meetings because she perceived it as less distracting and overwhelming. Another student from the focus group emphasized that face-to-face meetings were very important to him in order to get to know the other participants in a study group better. It was also discussed whether it is important to meet regularly or whether students might prefer more flexible meetings. The "ideal" group size should be 3 or 4 students according to the participants of the focus group. This statement is consistent with the recommendation from the literature that smaller groups are more likely to promote the productivity of individual group members than larger groups (Odo et al., 2019).

Concerning the general requirements for a tool for group formation, the students indicated that they are in general not reluctant to use such a tool, but that aspects such as transparency and trustworthiness are important to them and that the tool should be restricted to fellow students. The students also mentioned that using a tool for group formation should not take more than 10 to 15 minutes of their time.

As described above, the ten categories of the focus group were used as a basis to identify specific factors that may be important for group formation and to develop respective questionnaire items for them as described in the previous section. A total of 20 factors were found this way. The items that each describe the importance of one specific factor were then used in an online survey. Table 1 shows the factors and summarises the descriptive statistical analyses regarding the item prioritisation: Shown are the averaged agreement with an item and the frequency of mention in the evaluation of the factors. In addition, the corresponding category from the focus group is given for each item. Note that while group size was mentioned in the focus group, the question of an appropriate group size was not listed in the online questionnaire. As the statements from the focus group correspond with recommendations from the literature, a group size of 3–4 students was decided in advance instead.

The following five factors received the highest average agreement (cf. Table 1): "Sense of Duty", "Attitude towards Reliable Attendance of Meetings", "Attitude towards Regular Meetings", "Preference for Online Meetings", and "Accuracy in Working". The five factors that were mentioned most frequently include "Common Goals", "Sense of Duty", "Attitude towards Reliable Attendance of Meetings", "Preference for Online Meetings", and "Goal-Orientation and Perseverance".

In the questionnaire, students were also asked for their attitudes regarding study groups ("I like learning in study groups"), and how much experience they had with learning in study groups ("I have often learned in study groups"). Both items were again rated on the same 5-point Likert scale as described in Section 3.1. The average agreement regarding the first item was 3.24 (SD = 1.25), the average agreement regarding the second item was 3.56 (SD = 1.33). In addition, students were also asked whether they could imagine using an application or tool for finding a study group ("I could imagine using an application to find a new study group."). The average agreement regarding this item was 3.6 (SD = 1.2).

Table 1: Factors for Group Formation and Items used in the Online Study, along with Descriptive Data for Prioritisation.

Factor	Category in Focus Group	Mean	SD	Frequency
Common Goals	Common Goals	3.88	1.04	74
Homogeneity with regard to Gender	Sociodemographic Criteria	1.24	0.69	1
Homogeneity with regard to Age	Sociodemographic Criteria	2.25	1.23	10
Preference for Online Meetings	Organisation of Study Groups	4.04	0.89	50
Attitude towards Regular Meetings	Organisation of Study Groups	4.19	0.86	31
Setting one Appointment per Week	Organisation of Study Groups	3.26	1.25	9
Attitude regarding the Distribution of Tasks	Organisation of Study Groups	3.64	1.08	20
Attitude towards Reliable Attendance of Meetings	Attitude towards Reliability	4.25	0.89	51
Similarity in Personality	Interaction with Others	2.94	1.00	10
Difference in Personality	Interaction with Others	2.74	0.94	7
Similarity in Extraversion	Personality Traits	2.73	1.07	8
Difference in Extraversion	Personality Traits	3.16	1.03	7
Sense of Duty	Personality Traits	4.26	0.76	73
Accuracy in Working	Personality Traits	3.91	0.95	26
Common Interests	Interaction with Others	2.73	1.20	9
Common Hobbies	Interaction with Others	2.16	1.08	1
Goal-Orientation and Perseverance	Personality Traits	3.78	0.93	35
Pursuing of Goals despite Setbacks	Personality Traits	3.54	1.06	6
Consideration of Health Limits	Consideration of Health Limits	3.85	1.00	18
Similar level of Knowledge	Knowledge and Skills	3.12	1.15	18
Different level of Knowledge	Knowledge and Skills	2.81	1.07	11

3.3 Selection of Relevant Factors for Group Formation

The analysis of students' needs and perceptions regarding study groups presented in the previous sections formed the basis for the development of a prototype. In particular, based on the analysis, the selection of factors for group formation was made. This selection was made in two steps: Firstly, the averaged agreement was used, i. e., the extent to which the students agreed with the presented items. Secondly, it was examined how often the students had counted a factor as one of the three most important factors in total.

The following three factors were selected since they showed both, a high averaged agreement and a high frequency of mention: "Sense of Duty", "Attitude towards Reliable Attendance of Meetings", and "Preference for Online Meetings". It should be noted that the factor "Common Goals" was also considered as a criterion for group formation, as it was mentioned by most students ($n = 74$) as one of the three most important criteria for study groups. Interestingly though, the mean agreement was lower and the factor also had a higher standard deviation than the three factors that were ultimately chosen for group formation. It can therefore be assumed that this factor was less important for the entire sample which is why it was not considered for the algorithm for group formation here. In addition, difficulties with regard to the measurement of "Common Goals" also complicated the selection of this factor. The online study gave students the opportunity to mention in free text possible goals that they personally have when learning in study groups. A wide range of different goals were mentioned, such as a general exchange of information about university courses or the encouragement of interdisciplinarity. These findings indicate that students are pursuing study groups with different objectives. However, it is unclear how to summarise or operationalise these goals. To collect data or preferences on this factor from students, further analysis is needed.

In summary, it seems to be particularly important for students that the other people are similarly dutiful or conscientious, that they have a similar attitude regarding the reliable attendance of meetings, and a similar preference for online meetings. Thus, an algorithm for group formation should form groups that are as homogeneous as possible regarding these factors.

4 DEVELOPMENT OF A PROTOTYPE FOR GROUP FORMATION

The prototype consists of two components: the student front-end for allowing students to register and

for asking for their preferences, and a back-end for the group formation and sending notification emails to the students containing contact information of their recommended fellow students for a study group.

The student front-end was developed as a simple web-application using Spring Boot. It allowed students to register before a deadline, and stored all data in a database. Shibboleth Single-Sign On was used to restrict usage to students enrolled at the same university and to receive their (validated) names and email addresses. The registration required students to fill out a form that on the one hand included administrative data such as their name, email address, university and semester (all pre-filled). Further questions were developed to operationalise the three factors for group formation found in the previous section: Two questions were developed to measure preference for online meetings, and three items to measure the attitudes towards the reliable attendance of meetings in a study group. In addition, the six-item conscientiousness scale of the 30 item short version of the German NEO Five-Factor Inventory (Körner et al., 2008), based on the English NEO Five-Factor Inventory (Costa and McCrae, 1989), was used to assess the sense of duty. Two further items asked for the importance of the grade and the envisioned grade for that course. The form thus comprised a total of 17 items which are listed in Table 2.

The back-end was developed as a stand-alone Java application that needs to be invoked (manually) after the registration deadline to compose study group recommendations using a genetic algorithm approach. A genetic algorithm was chosen, because this type of algorithm performs well (also for large data sets) and has been used successfully by many previous studies on group formation (Krouska et al., 2019). For each course, the grouping algorithm uses the data of the registered students on online preference, their attitude towards reliability, and conscientiousness for the fitness function to form homogeneous groups, i. e., the average differences on the answers for the three factors should be minimal (Schenk, 2022). The implementation of the genetic algorithm is inspired by a previous study using a genetic algorithm for the formation of student groups of three (Moreno et al., 2012), the probability parameters for crossover (1.0) and mutation (0.5) were determined systematically by an evaluation with test data (Schenk, 2022). The genetic algorithm composes groups of three students as requested in the focus group. If the number of students is not a multiple of three, in the final step one or two "fourth students" are added to the best fitting groups. After all students have been assigned to groups, the tool sends emails to all students containing the names and email addresses of their fellow students of the respective recommended group and asks to contact them.

To ensure that the genetic algorithm actually achieves a higher fitness (i. e., forms more homogeneous groups regarding the three factors) than, for example, a random algorithm, the algorithm was evaluated using randomly generated data. A comparison was made between the genetic algorithm, a backtracking (brute force) algorithm (which considers all the options for grouping and then selects the one with the best fitness), and a random selection of students. The backtracking method is capable of finding an optimal solution for small groups and was used to estimate how close the genetic algorithm could come to that solution; however, it cannot be used effectively with more than 30 students.

For comparing the three algorithms, the number of students was systematically varied and the fitness values (calculated via the fitness function which indicates how homogeneous groups are with regard to the three factors) were compared with each other. The evaluation showed that the genetic algorithm does not achieve a better fitness for a smaller number of students (7–11 students) than a random selection. From a number of 12 students onwards, the genetic algorithm achieved a better fitness and it was able to achieve better fitness values in less than two minutes for a number of 3,000 students (Schenk, 2022).

5 EVALUATION IN A CASE STUDY

The prototype and the proposed factors were evaluated in two different first-semester Bachelor's courses in a field study at Technical University of Munich (first-semester computer science course, CS in the following, approx. 1,500 students) and Aalen University of Applied Sciences (math course, approx. 80 students) in winter term 2022/2023 in Germany. Both courses were attended by students of different courses of study.

5.1 Method

For both courses the prototype was made available to students in the first week of the semester and the registration was open for one week. In the math course the study was announced by the teacher and in the CS course by one of the authors. The composed groups were announced using email on November, 1st (beginning of the third week of the semester).

These two courses were selected, to investigate two hypotheses: 1) study groups formed by the proposed algorithm are perceived as better and persist longer

Table 2: Items used in the Web-Application (translated from German into English).

Item Formulation	Response Format
Your Name	Free text field (prefilled)
Your Email Address	Free text field (prefilled)
For which university are you looking for a study group?	Free text field (prefilled)
Which semester are you in?	Drop-down menu (1,2,3,4,5,6,>6)
I prefer to learn with a study group in presence.	5-point Likert scale
I prefer to learn with a study group online.	5-point Likert scale
When I am in a study group, I try to attend every meeting of the study group.	5-point Likert scale
It is important to me that other people in a study group attend every meeting.	5-point Likert scale
It is important to me that other people in a study group are willing to cancel other appointments for attending meetings of the study group, if necessary.	5-point Likert scale
I keep my belongings clean and neat.	5-point Likert scale
I'm pretty good about pacing myself so as to get things done on time.	5-point Likert scale
I try to perform all the tasks assigned to me conscientiously.	5-point Likert scale
When I make a commitment, I can always be counted on to follow through.	5-point Likert scale
I am a productive person who always gets the job done.	5-point Likert scale
I never seem to be able to get organised.	5-point Likert scale
A good grade is very important to me.	5-point Likert scale
My target grade for this module:	Drop-down menu (Grade A, Grade B, Grade C, Grade D, no target grade)

than randomly composed groups, and 2) there is no difference in these terms between a course with a very high number of students and a course with a lower number of students. To investigate the first hypothesis, the students of the CS course were either assigned to a study group formed by the genetic algorithm or to a study group formed by a random process. Due to the size of the math course (and "only" 26 registered students for the study), all groups were composed using the genetic algorithm for that course.

To evaluate both hypotheses, a web-based questionnaire was developed and a personalized link was sent to all registered students four weeks before the end of the term and a reminder one week later. The questionnaire was accessible online for three weeks. It included items asking whether there had been contact to other members of the study group and, if so, how often and regularly the students had met. Additionally, items were included asking how satisfied students were with their study groups. To also assess how pleasant the atmosphere in the group and the cohesion was perceived, the four items of the Participative Safety scale of the German version of the Team Climate Inventory were used (Brodbeck et al., 2000). In addition, the online questionnaire included the eight items of the "Cohesion" scale of the German questionnaire on teamwork (Kauffeld and Frieling, 2004, "Fragebogen zur Arbeit im Team").

5.2 Results

The prototype was used by a total of 287 students (CS course: 261, math course: 26), 151 of whom were in their first semester (CS course: 133, math course: 18). For the CS course, 87 groups were composed (44 randomly and 43 by the genetic algorithm) and for the math course 9 groups were composed.

There were 39 persons from both universities participating in the evaluation study (CS course: 31, math course: 8). The students' ages ranged from 18 to 29 ($M = 20.74$, $SD = 2.62$). The majority of the students ($n = 31$) was in their first semester. 17 students were in a randomly composed group (only CS course), and 22 in a group that was composed by the genetic algorithm (CS course: 14, math course: 8).

Out of the 39 students, 15 stated that contact had been established with all members of their study group (CS course: 11, math course: 4), 7 stated that they had been in contact with some members of their study group (CS course: 4, math course: 3), and 17 students stated that there had been no contact at all (CS course: 16, math course: 1). Out of the 22 students who replied that a contact had – to some extent – been established,

14 students stated that they had not yet had a meeting with other members of their group, four students stated that they had met less frequently than once a week, three students stated that they had met once a week, and one person stated that they had met multiple times a week.

Due to the small number of people who took part in the final questionnaire and had actually met in their groups, no further in-depth analyses regarding the two formulated hypotheses were conducted.

A free text field gave people the opportunity to indicate difficulties they had encountered in connection with their study group. Two students stated that other members did not reply, and thus no contact could be established. Furthermore, it was mentioned that people did not have time to schedule a meeting for studying: One student remarked that an actual meeting for studying did not happen because the others could not find the time. Another student stated that no meeting took place because one person from the study group never got in touch and the other was too busy. To facilitate an exchange, it was suggested to pay more attention to a common study program and interests.

6 DISCUSSION

The requirement analysis described in this paper identified three factors that are important to students. These factors can be described as person-related factors that relate to personality traits of the group members and to their preferences regarding the organisation of the meetings.

In general, the current work suggests that students themselves prefer a homogeneous group composition regarding the mentioned factors. This may be due to an enhanced trust with group members that are similar to oneself, as previous research literature suggests (Ennen et al., 2015) and is in line with previous findings that have shown that when group formation is left to students themselves, they tend to form more homogeneous groups, e. g., regarding person-related factors such as level of knowledge or sociodemographic variables (Razmerita and Brun, 2011; Freeman et al., 2017). It is conceivable that a similar level of conscientiousness may also result in a similar perception of problems, which has already been shown to be important for self-organised collaborative learning (Melzner et al., 2020).

In contrast to previous studies, the current study also highlights the importance of students' preference for either face-to-face or online meetings: The group formation algorithm proposed in this study also takes the factor "Preference for Online Meetings" into account which seems to be very important for many students. This is a factor that has not been investigated in particular by previous research literature. The fact that students attribute high importance to this factor may be due to the COVID pandemic during which meetings in person were hardly possible or not possible at all; as a result, online meetings and in particular, online learning became increasingly important and commonplace for students (Shaid et al., 2021).

Two limitations should be noted regarding these findings: Firstly that it cannot be clearly stated whether the three factors identified in the requirement analysis are indeed the factors that are most important to the population of students since this was a purely descriptive statistical analysis. Efforts were made to obtain a representative sample by addressing various students at multiple (German) universities. However, the final participating sample of students was influenced by self-selection and it is not clear how representative the data is for all students with an interest in study groups since a majority of participants seemed to study STEM subjects such as computer science or media informatics and some participants stated that they themselves were not actually interested in learning in study groups. Furthermore, only one focus group of six people was used to select potentially relevant factors. Although care was taken to select students from different disciplines who already had experience of learning in self-organised study groups, it cannot be ruled out that other (possibly relevant) factors would have been mentioned in a further survey with different people. Due to restricted resources, the inductive categorisation analysis for analysing the focus group was carried out by one person which limits the reliability of this analysis.

Lastly, the results of the requirement analysis may be biased because of the already mentioned potential impact of the COVID pandemic: the focus group and the online study took place in the beginning of 2022 and, therefore, might be influenced by the COVID pandemic. It cannot be definitively stated whether these findings are still valid in current times when everyday life is no longer restricted by the pandemic.

Secondly, it should be noted that the factors identified in the requirement analysis are only based on students' own perceptions and therefore do not necessarily have to have a (significant) positive impact on the learning experience. As pointed out before, the aim of the present study was in particular to take students opinions into account since they are probably best placed to assess which factors they perceive as beneficial or detrimental to learning in study groups. However, students may not only pursue the goal of achieving learning success with study groups – the results of the requirement analysis indicate that students

may pursue various different goals. It is therefore possible that students consider certain factors to be important for study groups which may not necessarily be related to an improved learning experience or academic outcomes but to other goals that students had in mind.

The evaluation study attempted to address this finding by using different items in the online questionnaire to assess not only learning achievements, but also aspects such as the sense of cohesion within the study group. However, no clear statements can be made as to whether the group formation carried out by the genetic algorithm (which forms homogeneous groups according to the three factors) is also better in terms of learning success or group cohesion than the group formation carried out by a random algorithm due to the small sample size in the evaluation study. The questions of whether groups formed by the proposed algorithm are perceived as better and last longer and whether there is a difference between the two courses of different size could thus not be answered. Nevertheless, the evaluation study provided certain insights into the challenges that may hinder students from learning with their study groups and that should be taken into account when designing a prototype for group formation of study groups.

First of all, it should be pointed out that a large number of students stated in the evaluation study that contact with other group members did not take place at all. This may be due to the design of the prototype where the students were only given the names and the email addresses of the other group members as well as a prompt to establish contact. The actual establishment of contact was ultimately left to the students themselves. It is possible that the students felt reluctance to write to other students they did not know or that there was a general lack of clarity about who should write a message to the others first. Another possibility is that contacting students via email (as configured in the university's directory; default was the university email account) is generally not convenient for them. They may find this way of communication more complicated and they may not check their emails often enough to respond in a short period of time. Another reason could be that the study group assignment was made too late in the semester (beginning of the third week) and groups might already have formed on other ways. Nothing was noted about this in the evaluation questionnaire.

Even if the contact was established, scheduling difficulties also posed a challenge for the students which sometimes prevented them from studying together. There are several such comments in the evaluation study. The problem that students like to learn with others but cannot find a suitable time slot was also discussed in the focus group. It was suggested by the participants of the focus group that the tool could ask students about the possible free time slots or preferred days. Especially for students who want to study regularly, it could be important to find a common time slot per week. Though, the results of the online study showed that one shared meeting per week was less important to students than the other factors mentioned. Hence, features for finding an appointment, were not further considered in the design of the prototype. But since the courses in which the prototype was presented turned out to be quite diverse regarding the attending students' semesters and courses of study, students might have been overwhelmed with the task of finding an appointment on their own. Thus, taking information about the students' semester or course of study into account could further reduce the difficulties of scheduling an appointment. This assumption is supported by one student commenting in the evaluation that all three people in their study group studied a different major which caused problems in scheduling.

In general, it seems as if there is an interest by a notable proportion of students who used the prototype in the beginning of the semester to find a study group (CS course: 261 of approx. 1,500 students, 17 % vs. math course: 26 of approx. 80 students, 32 %). This however, can only be seen as a rough tendency, as the interest depends on various factors such as the way of advertising, the university size or types, and the concrete courses.

7 SUMMARY AND OUTLOOK

The basic aim of this study was to gain a better understanding about the formation of study groups. In particular, two questions were addressed: The question of students' needs in relation to the factors used for the formation of study groups and the question of possible challenges that need to be considered when forming study groups. Through a requirement analysis it was examined how students imagine their ideal study groups. Study groups were perceived as most useful by students when being as homogeneous as possible regarding the three factors "Sense of Duty", "Attitude towards Reliable Attendance of Meetings" and "Preference for Online Meetings". Based on this finding, a prototype was implemented using a genetic algorithm for group formation. To evaluate the prototype, a field study was carried out. Due to a small sample size in the final questionnaire, the main questions of how well the groups formed by the prototype actually learn together and whether there are differences between large

or smaller university courses could not be answered, but difficulties were identified that should be considered in the future: On the one hand, that contact is often not established when the task of making contact is left to the students themselves. On the other hand, that even if contact is made, it does not also mean that meetings of the study group will take place. This is probably due to scheduling difficulties.

The paper thus provides initial indications of what may be important to students when learning in study groups and what needs to be considered when implementing a tool for the formation of self-organised study groups. Future studies should, for example, examine which goals students pursue with learning in study groups. The present work indicates that there are apparently different goals that motivate students to learn in study groups, and that common goals may be important for group formation. In addition, future research would be needed to examine how the students perceive learning in the groups formed by the genetic algorithm presented in this paper. With regard to the implementation of a tool for the formation of study groups, the question of how to facilitate contact remains to be answered. Future studies could explore this question further and, for example, try to get information through surveys about what could motivate students to contact others and what tends to prevent them from doing so. In addition, it could be helpful to consider characteristics such as the number of semesters or the subject of study when forming study groups in order to make it easier for the students to schedule meetings.

All in all, an application for finding study groups seems to be considered useful by the students – the fact that the prototype presented in this paper was used by 287 students overall indicates that there is a need for such a tool in higher education. Nevertheless, further research is needed to fully ensure the expectations of students – especially regarding their different goals – are met and to facilitate the contact establishment and scheduling of meetings.

The source code of the registration form (incl. the questionnaire) as well as the grouping tool (Schenk and Strickroth, 2024a), and the evaluation questionnaire as well as the raw data (Schenk and Strickroth, 2024b) are available on Zenodo.

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