

Adapting Online Group Formation to Learners' Conscientiousness, Agreeableness and Ability

Chinasa Odo*
r01cro17@abdn.ac.uk
University of Aberdeen
Aberdeen, UK

Judith Masthoff
Utrecht University and
University of Aberdeen
Utrecht, the Netherlands

Nigel Beacham
University of Aberdeen
Aberdeen, UK

ABSTRACT

This paper focuses on the impact of conscientiousness, agreeableness, and ability for the formation of heterogeneous learning groups in supporting lifelong learning. It presents a study in which participants assigned learners to groups to investigate whether these, and more importantly, how they use learner personality and ability in group formation and inspire future algorithms.

CCS CONCEPTS

• **Human-centered computing** → **Collaborative and social computing**.

KEYWORDS

Group formation, Collaborative learning, User study, Adaptation

1 INTRODUCTION

Learning is seen as a continuous process which starts from birth and terminates at death. According to the Commission of the European Communities [8], lifelong learning is defined as all forms of voluntary or self-motivated learning undertaken by adults after their initial education and training. Lifelong learning encompasses continuing education and professional development programs for self-sustainability, competitiveness and employability. The aim is to support individuals to remain relevant in the field, since it is not possible to acquire all the required knowledge during the traditional school years. With the emergence of technology, lifelong learning has no barrier on how we receive and gather information, collaborate and communicate with others. According to Laal [25], lifelong learning is diverse, adapted to individuals and available throughout life unlike traditional learning. Lifelong learning is often not teacher lead in contrast to traditional classroom learning, but individual learners can collaborate with others to enhance their understanding and skills.

Traditionally, teachers have been the leading source of knowledge transmissions in the learning environment. As technology becomes more advanced, the opportunity provided by e-learning

becomes a factor in facilitating collaborative learning. These opportunities are accompanied by approaches that emphasize the learner as the main agent of learning. Learners in this situation come together to make learning socially interactive rather than a transmission of pre-packaged lectures [16]. When learners engage in online collaborative learning, it may help to induce positive affect by providing an opportunity for active participation in achieving the learning objectives within the group [4]. Collaborative learning is a situation where two or more learners come together to facilitate learning [11]. The aim is to provide learning activities that give learners opportunities to interact, share and process information. A collaboration paradigm promotes problem-solving, critical thinking and facilitates the development of interaction between learners [49] and promotes an overall participation of all learners [5].

The collaborative environment enables teachers to be facilitators who assist in generating and sharing learning content, and not to control the delivery and pace of learning [42]. Teachers ensure that the core concepts and practices of the subject domain are fully integrated, and are also responsible for creating the environment through which effective collaboration can be possible [40]. A learner can engage in discussions in which they construct and share the understanding of content through different methods [21]. This is inspired by the Zone of Proximal Development by Vygotsky [47]. Vygotsky believes that any learning encounters have a previous history, and he emphasized the importance of learning through interactions with others rather than individual work. Supporting Vygotsky is the cognitive developmental theory of Piaget [41] which noted that the cognitive development is a progressive transformation of mental developments caused by biological advancement and those acquired within the environment. In a social learning system also, Bandura [2] noted that new patterns of behaviour can be acquired through direct experience or by observing the behaviour of others. The interaction within the online learning environment may induce positive changes in learners' affective state.

This paper investigates automatic group formation, to improve the effectiveness of collaboration in supporting the learning process within and beyond the walls of educational system. In particular it investigates to what extent learners' conscientiousness, agreeableness and ability should inform group formation and in which way.

2 RELATED WORK

2.1 Online Collaboration

Online collaboration, just like a conventional group, is formed when two or more people interact and influence each other's discussion

for the purpose of learning and understanding learning contents completely [11, 12]. In an online collaboration, the discussion is central to learning. It operates in an environment that may be asynchronous and is independent of place. Through collaborations, learning is simplified, because members will strive to motivate and support one another through discussion and elaboration on learning activities. The theory of online collaborative learning by Harasim [17] believed that learners solve problems collaboratively through discourse rather than recite what they think is the right answer. The social environment influences the learning process [27] and enables learning to be achieved through the process of observational learning [3]. The social learning theory of Bandura [2] emphasizes the role of environmental influence in learning. It is imperative that learners with the same cognitive characteristics be matched together to promote learning and foster effective team performance [1].

2.2 Group Formation

Bringing learners together to form a group in terms of ability and experience has been found to have a positive effect on performance [33]. Group roles are largely dependent on learner's personality and experience [36]. Nazzaro and Strazzabosco [36] observed that some learners are shy, some are impatient while some are confident, but what matters in a group is communication among members of the group. According to Sherif and Sherif [43], groups are constituted to provide individuals with mutual support and the opportunity to solve difficult problems. Groups are also formed to bring together different characteristics of individuals [11]. The aim is to have a good blend of learners who would share ideas to achieve optimal learning outcomes [14]. Moreland et al. [35] regard group composition as a cause that can influence other aspects of group life, for instance, group structure, dynamics and performance. The study by Vrioni [46] shows that group learning provides an opportunity for negotiation which creates an environment necessary for learning. Moreland et al. [35] believe that if a group is effectively created, an ideal group can be formed where learners can work together for the optimal satisfaction of a set of learning objectives. A study by Odo et al. [39] advocated for learners' affective state being taken into account when forming collaborative groups.

2.3 Heterogeneous Groups

For groups to be heterogeneous, a distribution is needed of learners over the groups which provides diversity, for example in age, gender, abilities, skills, cultural background, personality traits, etc, rather than the same characteristics being together in one group [48]. According to Houldsworth and Mathews [18], group performance is influenced by the degree of heterogeneity in formation. They found that diverse groups perform more consistently. However, they noted that most groups possess certain elements of process loss as well as aspects of process gain which often tend to balance each other out as the group progresses. Considering the heterogeneous aspect of group composition, a study by Moreland [34] suggested that age, gender, and cultural background should be considered as the most important demographic factors for group formation. Supporting [34] are studies by Jackson et al. [19] and Lai [26], which maintained that group composition, with respect

to gender and ability, is an important factor. Also, a study by Davis [9] suggested a random selection to exploit heterogeneity, to have a mix of males and females, verbal and quiet, the cynical and the optimistic learners in a group. Cen et al. [7] found that heterogeneous groups with a diversity of skills and genders benefit more from collaborative learning than homogeneous groups. Several studies have been conducted on personality in group formation [15, 45].

Learners felt that in addition to ability, other learner characteristics such as personality needed to be considered. Based on this work, we decided to investigate alternative solutions to group formation using computational methods. We conducted a systematic literature review on group formation for collaborative learning [37] which investigated which learner characteristics are used in (automatic) group formation, and what algorithms are used to do the group formation. We found that the reviewed papers did not specifically consider which learner characteristics are important when forming a group, but tended to focus on a particular characteristic for group formation. Learning characteristics used included gender, learning style, interests, ability, knowledge, and personality. A variety of methods were used for automatic group formation (see [38] for details). The reviewed papers did not base their algorithms on studies with humans, nor did they evaluate the algorithms with humans. The work in this paper extends the related work by investigating in more detail which *combinations* of learner characteristics to use, and in which way, based on a study with learners.

2.4 Personality and Collaboration

Personality traits are habitual patterns of behavior, thought, and emotion that are relatively stable over time, differ across individuals, are consistent over situations, and influence behavior [24]. A good combination of personality traits may harness individual strengths and manage the weaknesses toward a common goal. Good and bad personality traits within a team may offset one another and build on each other and lead to synergies. Personality traits are an important aspect in group formation because, when personality differences are ignored, a team may not perform effectively. The theory in [13] supported team formation and describes how individual personalities interact at the group level. Individuals that differ in their personality traits exert various influences on group behaviour. This is supported by Lykourantzou et al. [29] who defined balanced groups as consisting of individuals with compatible personalities. The Myers Briggs Type Indicator is one tool to identify individual personality type, related to the communication and interaction within a group [20]. Personality traits influence the way individuals perceive, plan, and execute any activities [6]. Another type of personality model that exists is the so-called Big-five. This model distinguishes five distinct personality dimensions: agreeableness, conscientiousness, extroversion, neuroticism and openness to experience [22]. Understanding personality types when forming a collaborative group may be helpful to appreciate that people are different, with values, special strengths and qualities, and should be treated with care and respect. Personality traits are important determinants of human behaviour [22] and may therefore impact collaboration. McGivney et al. [32] noted that a combination of different personalities impacts group performance and interaction.

3 STUDY: USER-AS-WIZARD

The related work and our own earlier qualitative work [30] (we conducted a survey and focus groups) indicated that teachers and students felt personality traits and ability need to be considered in group formation. However, these studies only provide peoples perceptions on what they consider important, and do not show what people actually do when forming groups, assuming that the learner characteristics are known to them. This study investigates actual group formation. Many personality traits exist; here we focus on just two of these, namely conscientiousness and agreeableness, both of which seem relevant to collaboration. The intention is to repeat the study with other personality traits in future.

3.1 Design

This study used the user-as-wizard method [30], in which participants took the part of the adaptive system and had to assign learners to groups¹. Twenty four participants took part in the study, all were students with experience of group learning (10 undergraduates and 14 postgraduates; 6 of the postgraduates had also worked as teaching assistants and been involved in forming groups of students to work together in a project). They were presented with 12 learners and their individual learner characteristics and told that these learners differed in personality and ability. They were asked to put these learners into groups, in such a way that the groups would work well together².

All learners had common English male names, selected to avoid any influence of gender, ethnicity or religion. Three learner characteristics were used: ability (high, low, average), conscientiousness (high, low, and average), and agreeableness (high, low, average). Validated stories of personality traits of fictitious learners [10] were used to illustrate the personality traits (four stories depicting high and low levels of conscientiousness and agreeableness). These stories were shown by Smith et al. [10] to reliably convey personality types, so we can be confident that the participants will interpret the personality traits correctly.

Table 1 shows the learner characteristics and personality stories used and ability levels. We will use the following abbreviations: ABL = ability, CONS = conscientiousness, AGR = agreeableness. Each participant first assigned the 12 learners to 3 groups of 4 learners, next to 4 groups of 3 learners, and finally to 2 groups of 6 learners.

Whilst the literature and our previous work indicates that personality and ability are perceived to matter when forming groups, we wanted to better understand how these characteristics are used when forming groups, in order to be able to produce an algorithm for doing this automatically. So, we were not just interested in whether learner characteristics matter, but particularly in *how* they matter. Hence, we investigated the following overarching research questions:

RQ1 Is conscientiousness considered in group formation, and if so how?

¹Using this method for this purpose has limitations. These and the rationale for doing this anyway will be discussed in the paper conclusions.

²The instruction to participants was generic on purpose. We did not ask them to make a high performing group, as they may have disregarded the learning outcomes for the other groups. We did not ask them to make well-balanced groups with approximately equal conditions

RQ2 Is agreeableness considered in group formation, and if so how?

RQ3 Is ability considered in group formation, and if so how?

For each of these three learner characteristics (CHAR), we are interested to know:

- (1) Are high CHAR learners distributed evenly across the groups?
- (2) Are low CHAR learners distributed evenly across the groups?
- (3) Are individual groups balanced on CHAR, so is the number of low and high CHAR learners the same?
- (4) Is CHAR cohesion in individual groups considered?

This results in research questions RQ1.1–RQ1.4, RQ2.1–RQ2.4, and RQ3.1–RQ3.4.

Regarding even distributions, given there are 3 high CONS and 4 high ABL learners, an even distribution for high CONS and high ABL means when creating:

- 3 groups of 4: 1 high CONS learner per group; at least 1 high ABL learner per group
- 4 groups of 3: 1 high ABL learner per group; no more than 1 high CONS learner per group
- 2 groups of 6: 2 high ABL learner per group; no more than 2 high CONS learners per group

The high CONS case is similar for low CONS, high AGR, and low AGR; and the high ABL case is similar to the low ABL case.

Regarding cohesiveness, we believe that a group has better cohesion when the standard deviation of the group’s CHAR is smaller. We calculate the standard deviation by coding high CHAR as 2, medium 1, and low 0. This for example means that a group of 3 high and 1 low CHAR learners has worse cohesion than a group of 2 high, 1 medium, and 1 low CHAR learners, which has worse cohesion than a group of 1 high, 1 low, and 2 medium CHAR learners.

Table 1: Learner characteristics and personality stories used

Personality trait	Stories
Conscientiousness	High Charles, George, Kenneth. For example: Charles is always prepared. He gets tasks done right away, paying attention to detail. He makes plans and sticks to them and carries them out. He completes tasks successfully, doing things according to a plan. He is exacting in his work; he finishes what he starts.
	Low David, Henry, Larry. For example: David procrastinates and wastes his time. He finds it difficult to get down to work. He does just enough work to get by and often doesn’t see things through, leaving them unfinished. He shirks his duties and messes things up. He doesn’t put his mind on the task at hand and needs a push to get started.
	Medium Anthony, Brian, Edward, Frank, Ian, James
Agreeableness	High Anthony, Edward, Ian. For example: Anthony has a good word for everyone, believing that they have good intentions. He respects others and accepts people as they are. He makes people feel at ease. He is concerned about others, and trusts what they say. He sympathizes with others’ feelings and treats everyone equally. He is easy to satisfy.
	Low Brian, Frank, James. For example: Brian has a sharp tongue and cuts others to pieces. He suspects hidden motives in people. He holds grudges and gets back at others. He insults and contradicts people, believing he is better than them. He makes demands on others and is out for his own personal gain.
	Medium Charles, David, George, Henry, Kenneth, Larry
Ability	High Anthony, Brian, George, Henry
	Low Charles, David, Ian, James
	Average Edward, Frank, Kenneth, Larry

3.2 Results

Table 2: Personalities traits combined when forming collaborative groups (Conscientiousness and Agreeableness)

	Conscientiousness		Agreeableness		Group			
	High	Low	High	Low	1	2	3	4
3 groups of 4 learners	1	1	1	1	15	10	8	
	1	1	2	-	7	1	-	
	1	-	1	2	-	7	2	
	1	2	-	1	-	2	3	
	1	1	-	2	2	-	3	
	1	-	2	1	-	1	-	
	2	1	-	1	-	3	-	
	1	2	1	-	-	-	5	
	-	1	3	-	-	-	1	
	-	1	2	1	-	-	2	
4 groups of 3 learners	1	1	-	1	9	6	-	4
	1	-	1	1	2	7	6	-
	-	1	2	-	3	2	-	-
	1	1	1	-	8	-	3	4
	-	-	1	2	2	3	2	1
	3	-	-	-	-	2	-	-
	-	-	2	1	-	2	-	1
	1	-	2	-	-	1	4	-
	1	-	-	2	-	1	-	2
	-	1	1	1	-	-	4	5
2	1	-	-	-	-	2	-	
1	2	-	-	-	-	3	2	
-	2	-	1	-	-	-	5	
-	2	1	-	-	-	-	1	
2 groups of 6 learners	2	2	1	1	7	2		
	1	2	2	1	3	-		
	1	2	1	2	8	1		
	1	1	2	2	2	7		
	1	1	1	3	3	-		
	2	1	2	1	1	8		
	2	1	1	2	-	3		
	2	2	2	-	-	3		

Table 3: Learner ability combined when forming groups

	Ability			Group			
	High	Low	Average	1	2	3	4
3 groups of 4 learners	1	2	1	11	1	4	
	2	2	-	4	6	-	
	2	1	1	9	11	-	
	1	1	2	-	4	11	
	2	-	2	-	1	1	
	-	1	3	-	-	5	
	1	-	3	-	-	1	
	-	-	4	-	-	1	
	-	2	2	-	1	1	
	4 groups of 3 learners	1	1	1	9	17	10
1		2	-	6	1	3	1
2		1	-	4	-	1	3
-		2	1	4	-	-	3
-		1	2	1	-	3	1
2		-	1	-	4	-	-
1		-	2	-	2	7	5
2 groups of 6 learners	2	2	2	13	13		
	2	3	1	3	6		
	2	1	3	6	3		
	1	4	1	2	-		
	3	-	3	-	2		

Tables 2 and 3 show the groups created in terms of personality traits and ability respectively. For example, Table 2 shows that when allocating the learners to 3 groups of 4 learners, 15 participants put a high CONS, low CONS, high AGR, and low AGR learner in the first group they created.

RQ1 Is conscientiousness considered in group formation? Participants clearly took CONS into account.

- (1) *3 groups of 4.* Regarding RQ1.1, only 3 groups (out of 72) were created that did not contain a high CONS learner, showing participants distributed the 3 high CONS learners quite evenly over the groups. Regarding RQ1.2, only 10 groups did not contain a low CONS learner, so also low CONS learners tended to be distributed, but given the higher number of groups without a low CONS learner, it seems participants felt it was more important that a group contained a high CONS learner than that the low CONS learners were evenly distributed. Regarding RQ1.3, there was no balance of CONS in 26 groups, so balance does not seem to be an important consideration for CONS. Regarding RQ1.4, all groups created had good CONS cohesion; there were no groups combining 3 high with 1 low CONS, or 2 high with 2 low CONS.
- (2) *4 groups of 3.* Regarding RQ1.1, only 4 groups (out of 96) were created that contained more than one high CONS learner, again showing that participants tried to distribute these evenly. Regarding RQ1.2, there were 11 groups with more than one low CONS, again showing that high CONS was deemed more important than low CONS when balancing groups. Regarding RQ1.3, only 27 groups were balanced, so balance does not seem an important consideration for CONS. Regarding RQ1.4, with a group of 3, the worst cohesiveness is when 2 high CONS are combined with 1 low CONS, or the other way around. This only happened in 7 groups, so cohesiveness was fine.
- (3) *2 groups of 6.* Regarding RQ1.1 and RQ1.2, only groups were created that contained at least one high and one low CONS learner. This confirms that high and low CONS learners were distributed evenly over the groups. Regarding RQ1.3 and RQ1.4, half the participants allocated 2 high and 2 low CONS to the same group, seemingly trying to fully balance out the CONS levels across groups, now this now longer had a big impact on CONS cohesion (as the group size meant there were 2 medium CONS learners in those groups as well).

So overall, CONS was considered, and in particular high CONS learners are distributed evenly. CONS cohesion is important, and CONS balance is only considered when it does not impact CONS cohesion. The impact of CONS on group formation is not surprising, because as noted by [28], conscientiousness helps one to ensure and maintain harmonious relationships with others in the group. This is because conscientious people are usually well organized, prudent, thorough, neat and achievement oriented [31].

RQ2 Is agreeableness considered in group formation? AGR is clearly less considered than CONS when forming groups.

- (1) *3 groups of 4.* Regarding RQ2.1, 13 groups (out of 72) did not contain a high AGR learner, showing that participants paid more attention to evenly distributing high CONS across

groups than high AGR. Regarding RQ2.2, 16 groups did not contain a low AGR learner. Regarding RQ2.3, only 31 groups were balanced on AGR. Regarding RQ2.4, all groups created had good AGR cohesion; there were no groups combining 3 high with 1 low AGR, or 2 high with 2 low AGR.

- (2) *4 groups of 3.* Regarding RQ2.1, despite there not being enough high AGR learners to allocate even one to each group, in 13 groups more than one high AGR learner was allocated. This provides evidence that many participants were not trying to evenly distribute high AGR learners across groups. Regarding RQ2.3, they were also not trying to balance out AGR within groups, as none of these groups with two high AGR learners was allocated two low AGR learners. Regarding RQ2.2, 9 groups contained more than one low AGR learner, so low AGR learners were slightly more evenly distributed than high AGR ones. Regarding RQ2.4, there were 10 groups combining 2 high AGR with 1 low AGR or the other way around, so cohesion is not as good as for CONS, but still fine.
- (3) *2 groups of 6.* Regarding RQ2.1 and RQ2.2, all groups contained at least one high AGR learner, and only 3 groups (out of 48) did not contain a low AGR learner. So, in this case, there is more evidence of evenly distributing high AGR learners than low AGR ones. Regarding RQ2.3, only 18 groups contained the same number of high and low AGR learners, so there is less evidence of balancing than for CONS. Regarding RQ2.4, only 3 groups had bad cohesion, combining 3 low with 1 high AGR learners.

Overall, there is some evidence of AGR being considered, but clearly it is considered less than CONS. Balancing the AGR in a group does not seem to be a consideration, but there is some evidence that ARG cohesion matters. For AGR, cohesion seems to matter more than evenly distributing high and low AGR learners, though there is some evidence of the latter as well. Considering AGR in group formation is supported by the result of Lun and Bond [28] who noted that agreeable persons are more socially accommodating and thus achieve a higher level of relationship harmony with the others in the group.

RQ3 Is ability considered in group formation? ABLE is considered when forming groups, but less so than one may have expected.

- (1) *3 groups of 4.* Regarding RQ3.1, despite there being more high ABLE learners than groups, there were still 6 groups without a high ABLE learner. Similarly, regarding RQ3.2, there were still 4 groups that did not contain a low ABLE learner and many groups with 2 low ABLE learners. So, participants did not tend to evenly divide high and low ABLE learners across groups. Regarding RQ3.3, most groups tended to be as balanced on ability as possible (given there are 4 high and 4 low ABLE learners and only 3 groups, many groups had to have 2 of one type and 1 of the other). Regarding RQ3.4, there were no groups containing 3 high or 3 low ABLE learners, and cohesiveness was generally fine.
- (2) *4 groups of 3.* Regarding RQ3.1, given there were 4 high ABLE learners, one could have been allocated to each group. In 16 groups (out of 96) this did not happen. Comparing this to the results for CONS, in the case when there were as many high CONS learners as groups (3 groups of 4), clearly more

effort was taken to evenly divide the high CONS learners. Regarding RQ3.2, 18 groups did not contain a low ABLE learner. This result is quite similar to that for CONS. Regarding RQ3.3, only about half the groups (47) were balanced on ABLE, so this was less of a concern than it seems to have been for the smaller groups. Regarding RQ3.4, there were 19 groups containing 2 low and 1 high ABLE learner or the other way around, so cohesiveness was not that good.

- (3) *2 groups of 6.* Regarding RQ3.1, only 4 groups did not contain exactly two high ABLE learners, showing that participants allocated the high ABLE learners evenly over the groups. In contrast, regarding RQ3.2, 22 groups did not contain exactly two low ABLE learners, showing that evenly distributing low ABLE learners was deemed less important. Regarding RQ3.3, most people (13 out of 24) balanced ABLE, allocated 2 low and 2 high ABLE learners to each group. Regarding RQ3.4, only 2 groups had very bad cohesiveness, containing 4 low, 1 high and 1 average ABLE learners.

Overall, there is evidence of ABLE being taken into account, but not necessarily as expected. High and low ABLE learners were not distributed as evenly as could have been possible, and participants seem to have cared more about evenly distributing the high CONS learners than the high ABLE learners. However, the groups were quite similar in average ability, and the most frequently created groups were balanced on ability. Cohesiveness was an issue for the smallest (size 3) groups, where balance seems to have been more important, but was good for the larger groups. Most groups created combined low, average and high ABLE learners, which is in line with a study of Kardanova and Ivanova [23] who suggested that there needs to be a combination of low, average and high learners' ability to maintain good performance.

4 CONCLUSIONS

The success or failure of group collaboration depends on how well individual learners can work together toward a common goals. This paper has investigated the impact of personality (conscientiousness and agreeableness) and ability on actual behaviour when forming groups. The study showed that personality and ability are taken into account for group formation and, most importantly, provided insights on how they should be taken into account, which can be used in the design of an algorithm that adapts group formation to learner characteristics. Automated group formation is important particularly in a setting where there is no human teacher involved or where one human teacher is dealing with many learners. With the advance of lifelong learning, there is a move away from traditional classrooms and from teacher-led learning. Lifelong learners are motivated to keep learning and keep collaborating with others in order to be current in their professional lives. This continuous collaborative learning process will be easier when there is effective automatic group formation.

One limitation of this work is that participants were asked to form fictional groups, so did not get feedback on how well these groups ended up performing. The work in this paper provides initial insights for the algorithm, but further studies are needed to investigate the impact of adaptive group formation on learner motivation and achievement.

A second limitation is that the use of the User-as-Wizard approach presumes that participants are good at the task the system is supposed to perform, so that the behaviour of participants can be used as a basis for an algorithm. Our participants were students, and one could query whether they have enough experience to be able to make good groups, and whether it would have been better to use teachers (though some of our sample were in fact also teaching assistants). Our earlier qualitative studies had shown that students and teachers had very similar views on group formation. There is also not much evidence that teachers are better at this task (in fact in our earlier focus groups, students complained that teachers often got groupings wrong). The learners used in this study had more recent experience of what it is like to work in groups than teachers would have³. However, this does not mean the learners are necessarily good at this task. We did make the task easier for the participants than it normally would be for teachers, in that we provided detailed information on each learner in terms of their ability and personality, whilst teachers often may lack in particular the latter.

Whilst the User-as-Wizard method has this limitation, it was hard to conceive of a better way of gaining the insights we needed. An alternative method would have been to assign real learners to groups, and measure group collaboration and learning outcomes. However, this would be extremely difficult to do in a controlled way. Learners vary on many different characteristics (even in personality, the most popular Five Factor Model distinguishes five traits), so trying to investigate the influence of individual traits as well as other characteristics (e.g. ability, gender, ethnicity) with real learners is difficult. One possibility would be to find 12 learners who varied in exactly the way required for the study, whilst being equal on all other characteristics (such as gender, ethnicity, and other personality traits), which would be hard. We would also require multiple sets of such learners, to investigate the impact of different groupings. Another possibility would be to use a very large set of learners, allocate them to groups randomly, and use data analytics to determine the characteristics of the groups that performed best. However, the quantity of learners required would be enormous, and there could also be an influence of the learning task. On balance, using the User-as-Wizard seems a good approach to investigate which learner characteristics learners feel matter, and in which way. This narrows down the learner characteristics we ought to consider in future studies with real learners, making it more feasible to conduct such studies. Based on the results of this study improved hypotheses can be formulated, and tested with more participants including teachers.

Another possible limitation is the potential task complexity for study participants. The algorithms previously used for group formation are commonly based on finding constraint satisfaction solutions [37], which can be considered as a complex task even for computers. When letting this task be performed by humans, it is possible that they found it too hard to focus on multiple characteristics (constraints) at once, which may result in them only

considering other characteristics as secondary or not at all. However, participants did not complain about the task being too difficult, and the characteristics participants focused on, and the commonalities in their approaches, still provide valuable insights. The concern about task complexity is the reason why we only considered two personality traits in this study.

Future work will also include studies on other personality traits, more detailed analysis on the interaction between characteristics, and studies evaluating the impact of an adaptive group formation algorithm on the motivation and performance of learner groups and individual learners.

A system that performs automated group formation will also require the relevant learner characteristics, such as learner personality. This paper did not discuss how such characteristics can be obtained. For example, there are many ways to detect learner personality; see [44] for a review and for a very easy method to obtain learner personality using personality scales.

ACKNOWLEDGEMENT

The first author's PhD is supported by TETFund, Federal Republic of Nigeria.

REFERENCES

- [1] W Allinson and John Hayes. 2012. The Cognitive Style Index. In *Technical Manual and User Guide*. Vol. 33. Pearson Education Ltd or its affiliate, United Kingdom, Chapter 8, 119–135.
- [2] Albert Bandura. 1977. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review* 84, 2 (1977), 191–215.
- [3] Albert Bandura, Gian Vittorio Caprara, Claudio Barbaranelli, Maria Gerbino, and Concetta Pastorelli. 2003. Role of Affective Self-Regulatory Efficacy in Diverse Spheres of Psychosocial Functioning. *Child Development* 74, 3 (2003), 769–780.
- [4] Nigel Beacham and Bob Duncan. 2017. Development of a Secure Cloud Based Learning Environment for Inclusive Practice in Mainstream Education. *Cloud Computing 2017: The Eighth International Conference on Cloud Computing, GRIDs, and Virtualization* 2, 1 (2017), 1–4.
- [5] Nigel Beacham and Martyn Rouse. 2012. Student teachers' attitudes and beliefs about inclusion and inclusive practice. *Journal of Research in Special Educational Needs* 12, 1 (jan 2012), 3–11.
- [6] Luiz Fernando Capretz and Faheem Ahmed. 2010. Why Do We Need Personality Diversity in Software Engineering? *SIGSOFT Softw. Eng. Notes* 35, 2 (March 2010), 1–11.
- [7] Ling Cen, Dymitr Ruta, Leigh Powell, Benjamin Hirsch, and Jason Ng. 2016. Quantitative approach to collaborative learning: performance prediction, individual assessment, and group composition. *International Journal of Computer-Supported Collaborative Learning* 11, 2 (jun 2016), 187–225.
- [8] Commission of the European Communities. 2009. Adult learning: It is never too late to learn.
- [9] Barbara Gross Davis. 1993. *Tools for Teaching* (2nd ed.). Jossey - Bass Inc., Publishers, 350 Sansome Street, San Francisco, California. 1–449 pages.
- [10] Matt Dennis. 2006. *Adapting Feedback to Personality to Increase Motivation*. Technical Report. 7–9 pages.
- [11] Pierre Dillenbourg. 1999. What do you mean by 'collaborative learning'? *Americas Conference on Information Systems* 12, 1 (1999), 1–19.
- [12] Gloria J. Galanes and Katherine (Katherine L.) Adams. 2013. *Effective group discussion : theory and practice*. McGraw-Hill. 443 pages.
- [13] Jerry W. Gilley, M. Lane Morris, Alina M. Waite, Tabitha Coates, and Abigail Veliquette. 2010. Integrated Theoretical Model for Building Effective Teams. *Advances in Developing Human Resources* 12, 1 (2010), 7–28.
- [14] Hackman and R Wageman. 2005. When and how team leaders matter. *Research in organizational behavior* 26 (2005).
- [15] Terry Halfhill, Eric Sundstrom, Jessica Lahner, Wilma Calderone, and Tjai M Nielsen. 2005. Group Personality Composition and Group Effectiveness: An Integrative Review of Empirical Research.
- [16] Edmund J. Hansen and James A. Stephens. 2000. *The Ethics of Learner Centered Education: Dynamics that Impede the Process*. Technical Report. Emporia State University of Kansas, Kansas. 1–8 pages.
- [17] Linda Harasim. 2011. Learning Theory and Online Technologies. In *Learning Theory and Online Technologies*. Routledge Taylor & Francis.

³We did not measure the extent of this experience, which would be good to do in future studies of this kind. However, collaborative group work is used a lot in UK computing science programmes, including the classes the students were enrolled in, so the students would have had plenty of experience.

- [18] Chris Houldsworth and Brian P. Mathews. 2000. Group composition, performance and educational attainment. *Education + Training* 42, 1 (feb 2000), 40–53.
- [19] Susan E Jackson, Joan F Brett, Valerie I Sessa, Dawn M Cooper, and Et Al. 1991. Some differences make a difference: Individual dissimilarity and group heterogeneity as correlates of recruitment, promotions, and turnover. *Journal of Applied Psychology* 76, 5 (1991), 675–689.
- [20] David W. Johnson and Roger T. Johnson. 2004. *Assessing students in groups : promoting group responsibility and individual accountability*. Corwin Press. 206 pages.
- [21] David W Johnson, Roger T Johnson, Karl A Smith, and Karl Smith. 2013. Cooperative Learning: Improving University Instruction By Basing Practice On Validated Theory. *Journal on Excellence in University Teaching* (2013).
- [22] M. KankaraÅa. 2017. Personality matters. *Organisation for Economic Co-Operation and Development (OECD)* (2017).
- [23] Elena Kardanova and Alina Ivanova. 2014. Heterogeneity of the Educational System: an Introduction. (2014).
- [24] Saul M. Kassin. 2004. *Psychology*. Pearson/Prentice Hall. 826 pages.
- [25] Marjan Laal. 2011. Lifelong Learning: What does it Mean? *Procedia - Social and Behavioral Sciences* 28 (jan 2011), 470–474.
- [26] Emily R Lai. 2011. Collaboration: A Literature Review Research Report. , 49 pages.
- [27] Lev S. and Vygotsky. 1962. Thought and Language. *The Journal of Mind and Behavior Wintet* 8, 1 (1962), 175–178.
- [28] Vivian Miu Chi Lun and Michael Harris Bond. 2006. Achieving relationship harmony in groups and its consequence for group performance. *Asian Journal of Social Psychology* 9, 3 (2006), 195–202. <https://doi.org/10.1111/j.1467-839X.2006.00197.x>
- [29] Ioanna Lykourentzou, Angeliki Antoniou, Yannick Naudet, and Steven P. Dow. 2016. Personality Matters: Balancing for Personality Types Leads to Better Outcomes for Crowd Teams. In *Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW '16)*. ACM, New York, NY, USA, 260–273.
- [30] Judith Masthoff. 2005. The Pursuit of Satisfaction: Affective State in Group Recommender Systems. *International Conference on User Modeling* 35, 38 (2005), 297–306.
- [31] Robert R. McCrae and Oliver P. John. 1992. An Introduction to the Five-Factor Model and Its Applications. *Journal of Personality* 60, 2 (jun 1992), 175–215.
- [32] Sinéad McGivney, Alan F. Smeaton, and Hyowon Lee. 2009. The effect of personality on collaborative task performance and interaction. *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering* 10 LNICST (2009), 499–511.
- [33] Catherine Giggs Michael A. Campion, Gina J. Medsker. 2001. *Relations_Between_Work.pdf*. , 46 pages.
- [34] Richard L. Moreland. 1985. Social categorization and the assimilation of "new" group members. *Journal of Personality and Social Psychology* 48, 5 (1985), 1173–1190.
- [35] Richard L Moreland, JM Levine, and ML Wingert. 2013. *Creating the Ideal Group: Composition Effects at Work*. Taylor and Francis. 644 pages.
- [36] Ann-Marie Nazzaro and Joyce Strazzabosco. 2009. Group dynamics and team building. *DEVELOPMENT* 4 (2009).
- [37] Chinasa Odo. 2019. Group Formation for Online Collaborative Learning: A Systematic Literature Review. In *International Conference on Artificial Intelligence in Education*.
- [38] Chinasa Odo, Judith Masthoff, and Nigel Beacham. N.D. Heterogeneous Group Formation: Combining the right Learner Characteristics for Online Collaborative Learning. (N.D.). Unpublished manuscript.
- [39] Chinasa Odo, Judith Masthoff, Nigel Beacham, and Manal Alhathli. 2018. Affective State for Learning Activities Selection. In *Proceedings of Intelligent Mentoring Systems Workshop Associated with the 19th International Conference on Artificial Intelligence in Education, AIED 2018*. 1–10.
- [40] Rena M. Palloff and Keith Pratt. 2005. Learning Together in Community: Collaboration Online. *20th Annual Conference on Distance Teaching and Learning* (2005), 1–5.
- [41] J. Piaget. 1936. *The origins of intelligence in the child*. Routledge & Kegan Paul, London.
- [42] Tim S. Roberts. 2004. *Online collaborative learning : theory and practice*. Information Science Pub. 321 pages.
- [43] Muzafer Sherif and Carolyn W. Sherif. 1965. The Adolescent in His Group in Its Setting: Theoretical Approach and Methodology Required.
- [44] Kirsten A. Smith, Matt Dennis, Judith Masthoff, and Nava Tintarev. 2019. A methodology for creating and validating psychological stories for conveying and measuring psychological traits. *User Modeling and User-Adapted Interaction* (2019).
- [45] Bruce W. Tuckman. 1964. Personality Structure, Group Composition, and Group Functioning. *Sociometry* 27, 4 (dec 1964), 469.
- [46] Rudina Vrioni. 2011. Effects of Group Learning on the Academic Performance of University Students. *problems of education in the 21st century* 33 (2011).
- [47] Vygotsky. 1978. *Integration between learning and development*. Harvard University press, Cambridge.
- [48] Mona Zamani. 2016. Cooperative learning: Homogeneous and heterogeneous grouping of Iranian EFL learners in a writing context. *Cogent Education* 3, 1 (feb 2016).
- [49] Vicky Zygouris-Coe. 2012. Collaborative Learning in an Online Teacher Education Course: Leasons Learned. *ICICTE Proceedings* (2012).