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Tlhoale, Malefyane; Suhre, Cor; Hofman, Adriaan

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Using technology-enhanced, cooperative, group-project learning for student comprehension and academic performance

Malefyané Tlhoale^{a*}, Cor Suhre^b and Adriaan Hofman^c

^aTeaching and Learning with Technology, Tshwane University of Technology, Private Bag X680, Pretoria 0001, South Africa; ^bCentre for Learning and Teaching, University of Groningen, P.O. Box 800, 9700 AV Groningen, The Netherlands; ^cFaculty of Behavioural Sciences, University of Groningen, Landleven 1, 9747 AD Groningen, The Netherlands

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Cooperative learning may improve students' motivation, understanding of course concepts, and academic performance. This study therefore enhanced a cooperative, group-project learning technique with technology resources to determine whether doing so improved students' deep learning and performance. A sample of 118 engineering students, randomly divided into two groups, participated in this study and provided data through questionnaires issued before and after the experiment. The results, obtained through analyses of variance and structural equation modelling, reveal that technology-enhanced, cooperative, group-project learning improves students' comprehension and academic performance.

Keywords: interactive engagement methods; technology-enhanced cooperative learning; peer learning; motivation; deep learning

1. Introduction

Business firms already have moved towards encouraging employees to work in teams; educational institutions accordingly need to adapt cooperative learning methods to help prepare students for the workplace. In particular, these institutions should provide real-life preparations that enable students to transfer knowledge and skills acquired in the classroom to future employment settings. Thus, cooperative learning may offer an interactive engagement method that lecturers can use to develop students' critical thinking, teamwork, and interpersonal and communication skills.

The students in this study worked together in teams to produce positive learning outcomes using various technologies, including Blackboard, Facebook, Blackberry messenger (BBM; a free instant messaging application for Blackberry-to-Blackberry mobile phones), and WhatsApp messenger (a smartphone messenger that allows users to communicate without having to pay for short message services). Furthermore, they relied on grinding machines and microscope camera systems. Accordingly, this study examines the impact of technology-enhanced, cooperative, group-project learning (TECGPL) on students' learning and academic performance, in line with the principles of constructivist learning, and addresses a central research question: Can TECGPL improve students' comprehension and performance, and if so, how?

*Corresponding author. Email: tlhoalemj@tut.ac.za

Cooperative learning refers to an instructional strategy in which students actively work together in small groups to enhance learning (Abrami, Poulsen, and Chambers 2004), improve motivation, increase their understanding of course concepts, and improve their academic performance (Felder and Brent 1994; Parrenas and Parrenas 1993). However, to achieve the above, Fernandes et al. (2014) suggest that a shift from the lecture-based delivery model to a more interactive and student-centred learning environment is important when designing and developing courses. Furthermore, despite Donnelly's (2005) argument that incorporating technology does not guarantee effective learning, we follow Kearsley and Shneiderman (1998) and assert that TECGPL may facilitate students' learning in ways that would be difficult to achieve without technology. Finding suitable pathways to incorporate technology into education settings (Strommen and Lincoln 1992) and making technology part of a regular educational approach thus should encourage more successful learning. Technology has the potential to support constructivist learning and enable authentic, cooperative activities (Jonassen, Peck, and Wilson 1999). For example, technology can alter the presentation of metal shapes, such that engineering students gain a better view of joined materials and thus a better understanding of production processes.

2. Theoretical framework

As Biggs (1999) emphasises, knowledge is constructed through the learner's activities and interactions among lecturers, students, and peers. Constructivist learning reflects the principle that students discover their own truths through acting (Cooperstein and Kocavar-Weidinger 2004). That is, when they perform activities, students use their mental concepts to make sense of their experiences.

We consider constructivist learning theory relevant for this study for several reasons. First, students undertook a work-related, collective activity in which they were encouraged to accrue both content knowledge and social skills. Thus, they had opportunities to construct new knowledge while searching for explanations and answers to a work-related task at hand. Second, they shared ideas among themselves and compared what they were learning in their groups with what they discussed in class, which helped them build their knowledge and understanding of the content. They worked together as a team to achieve the intended learning outcomes (Neo 2005). According to Cooperstein and Kocavar-Weidinger (2004), the most effective way to encourage students to construct their own knowledge is to design a lesson that grants them an opportunity to discover their own truth. For example, students received an opportunity to discover on their own how the structure of material changes when heated, which should enhance their understanding and long-term knowledge retention.

3. Conceptual framework

We present our conceptual model in Figure 1 to detail the relationships among the variables in our study. The conceptual model indicates that peer learning could directly influence intrinsic motivation and deep learning as well as academic performance. Equally, the influence of peer learning on students' performance is mediated by intrinsic motivation and deep learning. The model also posits that help seeking could directly influence deep learning as well as academic performance. This implies that, the more students want to know, the more they understand the content and the more their academic performance would improve. In addition, the model suggests a negative relationship between extrinsic motivation and academic performance; and between surface learning and academic performance as well. That is, the more students use surface learning approach, the less they would academically perform. Similarly, the more they are extrinsically motivated,

Figure 1. Conceptual model.

Note: Paths denoted by dotted lines indicate negative relationships.

the less they would perform. Furthermore, the model proposes a possible relationship between students' individual characteristics and student performance. Hence, gender was included as a covariate in the model. This section is followed by the explanation of the variables and the hypotheses.

3.1. *Peer learning*

Some students learn best when they share ideas and learn from one another (Cooperstein and Kocevlar-Weidinger 2004; McKeachie 2002). Thus, when this strategy gets applied, less competent students have an opportunity to improve through discussions with more talented students. Equally able peers who hold differing ideas on an issue can also gain information through interaction. These strategies gradually are growing in popularity in higher education to help students achieve ideal learning outcomes (Boud, Cohen, and Sampson 1999). Peer learning encourages interdependent, as opposed to independent, learning (Keppell et al. 2006). Therefore, if used properly, it motivates students to interact beyond the classroom and learn from one another, which enhances their understanding of the content (deep learning) and ultimately improves academic performance.

3.2. *Intrinsic motivation*

Intrinsic motivation exists when the behaviour is performed out of interest, rather than for material or social gains. In this context, we regard intrinsic motivation as the satisfaction that students experience from certain activities at hand. During the learning process, lecturers can encourage students' intrinsic motivation through various interesting and challenging activities. For students to achieve a high level of intrinsic motivation, lecturers must relinquish some of their power in terms of controlling the classroom (Holley and Oliver 2010), such that they grant students an opportunity to construct their own understanding of the content. This autonomy should improve student's self-efficacy as well. Students with a high level of intrinsic motivation tend to use deep learning approaches (Baker 2004) and likely achieve greater academic performance.

3.3. *Deep learning*

A deep approach to learning can be realised through an intention to understand the focal content. Moving from surface to deep approaches is critical in higher education settings, where students are expected to be self-determinant in managing their own learning (Peters, Jones, and

Peters 2007). Constructive teaching alignment can encourage deep learning (Biggs 1999). That is, students should be equipped with deep approach learning skills, by (1) teaching methods that encourage their curiosity, sharing of ideas, and critical thinking skills to learn and achieve improved academic performance and (2) activities that align with the objectives and the level of understanding required, as stated in the course objectives. Higher order activities can close the gap between students who use deep versus surface learning approaches (Biggs 1999), in that the nature of the activities compels both types of students to think critically.

3.4. *Help seeking*

Previous research on help seeking largely focuses on psychological issues (Ayele 2011; Biddle et al. 2004), such as difficult intellectual or emotional adjustments in higher learning. Instead, we consider students who seek help from their peers or lecturers when they experience difficulties understanding the material or need information related to a specific topic during the learning process. Whereas previously help seeking may have been regarded as an indication of incompetence or dependence on others, modern theory suggests that help-seeking students are competent, because they regularly monitor their academic performance and realise their need for help when it arises (Newman 2000). Such students likely adopt a deep learning approach and may improve their academic performance more than students who do not seek help.

3.5. *Extrinsic motivation*

Extrinsic motivation exists when a person performs an activity only in exchange for a reward. Students might ‘perform extrinsically motivated actions with resentment or an attitude of will- ingness that reflects an inner acceptance of the value of the task’ (Ryan and Deci 2000, 55). For example, when students indicate that ‘getting a good grade in this class is the most satisfying thing for right now’, it implies they value and regard higher scores as important. Thus, extrinsic motivation does not always produce a negative effect; it can have benefits for some students. In general though, we believe that students who experience a high level of extrinsic motivation tend to rely on surface learning (Marton and Säljö 2005), such that their academic performance becomes unsatisfactory.

3.6. *Surface learning approach*

Surface learning entails a greater emphasis on rote learning and simple description (Warburton 2003). Although students may display both deep and surface approaches, depending on the focal activity (Atherton 2011), those who depend mostly on surface learning find it difficult to be creative or apply principles to a new situation. As a result, they achieve a lower level of academic performance.

Finally, we control for the effect of gender on academic performance by including it in the analysis. Thus, from our theoretical framework, we specify the following hypotheses:

H1. Peer learning has a significant, positive, direct effect on academic performance in the experimental group but not in the control group.

H2. Peer learning has a significant, positive, indirect effect on deep learning, through intrinsic motivation, in the experimental group but not in the control group.

H3. Peer learning has a significant, positive, indirect effect on academic performance, through deep learning, in the experimental group but not in the control group.

H4. Help seeking has a significant, positive, direct effect on academic performance in the experimental group but not in the control group.

4. Method

4.1. Context and participants

One hundred and eighteen physical metallurgy students in engineering from a higher learning institution in South Africa took part in this study, equally split between the experimental and control groups (59 participants each). In total, 67 (57%) students were men and 51 (43%) were women. All participants completed the consent forms required by the university ethics committee.

4.2. Instruments

To ensure that prior knowledge of students in the experimental group and control group did not differ significantly, we presented a pre-test on content before the experimental lectures were performed. The pre- and post-tests for this study were designed by the lecturer in charge of the course. To ensure validity, both tests were aligned with the learning objectives of the course content, and the alignment was verified by the researcher and the curriculum designer. These two formal tests were used to measure academic performance.

We collected the information regarding peer learning, intrinsic and extrinsic motivation, help seeking, and deep and surface learning with questionnaires (Table 1). The questionnaires used in the survey are presented in the [Appendix](#). These questionnaires included some of the motivated strategies for learning questionnaire (MLSQ) items developed by (Pintrich et al. 1991). We used the revised two-factor study process questionnaire (R-SPQ-2F; Biggs, Kember, and Leung 2001) to measure deep and surface learning. Although the R-SPQ-2F contains 20 questions, we selected 10 for this study (5 deep learning and 5 surface learning); the scales were reliable, with Cronbach's alpha values of 0.73 and 0.77, respectively (Table 1). The reliability of the variables varied from 0.73 to 0.87.

4.3. Study design and procedure

Students were assigned to a project in which they were to study and understand how the structure of material changes due to heat. Thus, they were to (1) join two parts of steel together, (2) prepare the sample for micro-structural characterisation, (3) investigate any material defects that would result in joint failure, and (4) write weekly reports about their findings and experiences. The report requirement was included to emphasise the importance of report writing as part of work roles. Students were randomly assigned to either the experimental or control group. At the beginning of the project, the lecturer explained the welding process to students but did not describe what would happen to the structure of the material. After three weeks of lecturing, the lecturer administered a pre-test to both groups. A day before the test, questionnaires were distributed to the students to complete.

4.4. Experimental group

The experimental group was further divided into groups of five participants to ensure effective learning. Each member of the group was assigned a role such as: (1) group leader, (2) information coordinator, (3) discussion coordinator, (4) hands-on coordinator, and (5) reporter. Members were responsible to lead the groups in these specific roles and at the same time expected to help other group members with other tasks. For example, group members were all expected to give instructions in their role capacities and also take instructions from other role leaders. That

Table 1. Descriptions, mean, standard deviations, and reliabilities of the study variables.

Variable	Description	Number of items	Pre-test mean	SD	Post-test mean	SD	α
Peer learning	When studying for this course, I often set aside time to discuss the course material with a group of students from the class (1 = not at all true of me, 7 = very true of me)	3	10.28	1.82	11.48	1.63	0.87
Intrinsic motivation	The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible (1 = not at all true of me, 7 = very true of me)	4	14.16	1.92	15.91	1.24	0.76
Extrinsic motivation	Getting a good grade in this class is the most satisfying thing for me right now (1 = not at all true of me, 7 = very true of me)	4	14.82	1.89	13.41	2.29	0.82
Help seeking	When I can't understand the material in this course, I ask another student in this class for help (1 = not at all true of me, 7 = very true of me)	4	14.88	1.87	16.37	1.94	0.84
Deep learning	I treat the course material as a starting point and try to develop my own ideas about it (1 = never or only rarely true of me, 5 = always or almost always true of me)	5	18.06	2.94	19.81	1.61	0.73
Surface learning	I see no point in learning material which is not likely to be in the examination (1 = never or only rarely true of me, 5 = always or almost always true of me)	5	21.58	2.04	16.77	2.39	0.77

is, they were also expected to seek for information concerning the task on hand as a group, exchange information as a group, and write a weekly report on their new finding and experiences as a group. The experiment ran for six weeks, thus, each member had a chance to change a role. What was more important in this study was the success of the approach; that is, the content knowledge and the skills acquired during the production process.

A discussion forum, created in Facebook, allowed members of the experimental group to contact one another if the need arose. Another discussion forum appeared on Blackboard. Students had to sign up for both discussion forums, which granted them means to communicate, even outside the classroom. As they worked in their groups, they were encouraged to search for information from various sources (e.g. books, Internet, and charts). During our observations, we realised that some students searched for information in the books, others accessed the Internet through their mobile phones, and still others contacted other groups through Facebook, BBM, and WhatsApp to ask for information. Therefore, we set rules that during class, students could use their mobile phones only to seek information about the content provided by other groups, such that their main discussions should be on Facebook or Blackboard, so that everyone could be involved. The discussions through Facebook and instant messages thus helped students to discover and differentiate among various phases of the heat treatment process and unique heat

Figure 2. Micrographs of students' samples obtained from the microscope camera system. (a) A hole and heat-affected zone defects. (b) Crack defect.

treatment techniques. Students also assimilated the learned information during discussions with their groups. They constructed their own understanding of heat treatment, related to what was explained in class. They also were discouraged from competing with one another, so that they could complete the project as a group. Thus, members of the team should have been equally interdependent, shared every new discovery as a group, and agreed on a common understanding of their new knowledge before the project could be completed.

During the analysis process students had to provide at least two micrographs of their samples, obtained from a microscope camera system. Figure 2(a) shows a defect in the joint (i.e. hole) and the heat-affected zone in the steel, as a result of the high temperatures that the steel part experienced. Figure 2(b) shows the material defect closest to the weld, which looks like a crack. These defects were investigated to determine the quality of the joint and whether they would result in material failure if the piece were used.

In addition to the micrographs of the samples, students explained the defects that could be observed with the naked eye and those visible under the microscope in their groups, to demonstrate their understanding of the quality requirements for the welded part. The two activities and the weekly reports were to be completed and submitted through the assignment tool in Blackboard. To complete these activities, students had to critically analyse their own thinking and new ideas, which ultimately led to the construction of new knowledge that promoted understanding and the application of concepts explained by the lecturer.

4.5. Control group

As did the experimental group, the students in the control group attended a lecture that explained the welding process but not describe what would happen to the material during the heating process. Unlike the experimental group, these students worked on the project as individuals. There was no plenary discussion by the lecturer at the end of the sessions; students were left to make sense of what they experienced entirely on their own. However, they were not restricted from asking question or for help. Though, their actions suggested little trust among other students, in that some of them actively sought to work on their own.

4.6. Analysis strategy

We started our analysis by determining whether there was any performance difference between the experimental and control groups, using an analysis of variance (ANOVA). In addition, we conducted *t*-tests to find differences between groups. Thereafter, LISREL 9.1 (Jöreskog and Sörbom 2012), a statistical software package that supports structural equation modelling (SEM) was

employed to analyse the data. Thus, in addition to the chi-square values, we evaluated the fit of the model with the root mean square error of approximation (RMSEA), standardised root mean square residual (SRMR), and comparative fit index (CFI); these three indices are the least sensitive to sample size (Hooper, Coughlan, and Mullen 2008). Regarding the RMSEA, values lower than 0.05 indicate good fit, 0.05–0.07 suggest reasonable fit (Steiger 2007), 0.08–0.10 means mediocre fit, and greater than 0.10 is poor fit (MacCallum, Browne, and Sugawara 1996). The SRMR scores range from 0 to 1.0, and well-fitting models achieve scores less than 0.05 (Diamantopoulos and Siguaw 2000), though Hu and Bentler (1999) argue that values between 0.05 and 0.08 are acceptable. Finally, for CFI, a value of 0.95 or more is indicative of good fit (Hu and Bentler 1999).

5. Results

We began with a significant test for the difference between the experimental and control groups. The ANOVA results revealed a significant difference ($F(1,116) = 73.51, p < 0.000$), whereas prior to the experiment, this difference was not significant (ns) ($F(1,116) = 0.002, ns$). We present the mean scores and standard deviations in Table 2.

The *t*-test results (Table 3) indicated that the control group scored higher ($M = 14.68$) than the experimental group ($M = 12.14$) on extrinsic motivation. As we expected, the experimental group scored higher ($M = 20.61$) than the control group ($M = 19.00$) on the deep learning variable. Generally, the experimental group scored higher than the control group on all variables except extrinsic motivation. However, the Pearson correlation results indicated a negative effect of surface learning on academic performance in the experimental group; the more students in the experimental group used the surface learning approach, the less well they performed academically. The results of the descriptive statistics appear in Table 3.

Next, we present the SEM results, starting with the outcomes of the general model, followed by the comparison between groups. The proposed model does not achieve satisfactory fit ([chi-square] $\chi^2 = 24.77$, (probability) $p = 0.002$, (degrees of freedom) $df = 2$, RMSEA = 0.133, SRMR = 0.08, and CFI = 0.96). To improve this fit, we added some relationships and also removed the non-significant relationships such as gender and surface learning from the model.

Table 2. Means and standard deviations for the two groups.

Group	<i>N</i>	Pre-mean	SD	Post-mean	SD
Experimental	59	51.97	5.76	68.76	9.65
Control	59	52.02	5.73	55.10	7.53

Table 3. Descriptive statistics of key variables.

Variables	Experimental group		Control group		Sig
	Post-mean	SD	Post-mean	SD	
Intrinsic motivation	16.31	1.33	15.51	1.01	0.00
Extrinsic motivation	12.14	1.98	14.68	1.84	0.00
Peer learning	11.88	1.64	11.08	1.54	0.01
Help seeking	16.85	2.12	15.90	1.62	0.01
Deep learning	20.61	1.49	19.00	1.30	0.00
Surface learning	16.85	2.43	16.69	2.37	0.73

According to the cut-offs discussed in the analysis strategy, the final model (Figure 4) indicated acceptable fit: $\chi^2 = 11.91$, $df = 8$, $RMSEA = 0.06$, $SRMR = 0.05$, and $CFI = 0.99$.

Peer learning emerged as the factor in the final model with the strongest impact. The direct effect of peer learning on intrinsic motivation ($\beta = 0.41$) exerted the strongest effect in the model, followed by a direct effect of peer learning on deep learning ($\beta = 0.38$). Peer learning also had a moderate direct effect on academic performance ($\gamma = 0.26$). The relationship between deep learning and academic performance was the third strongest direct effect ($\beta = 0.33$) in the final model. In addition, the indirect effect of peer learning on academic performance through deep learning ($\gamma = 0.33$) was stronger than the indirect effect through intrinsic motivation ($\gamma = 0.25$). The least strong but still significant ($p < 0.01$) direct effect appeared between help seeking and academic performance ($\gamma = 0.13$).

In line with our theoretical reasoning, extrinsic motivation correlated negatively with intrinsic motivation ($\gamma = -0.28$). The effect of extrinsic motivation on deep learning did not fit our predictions though; the results revealed a weak negative effect ($\gamma = -0.16$). Furthermore, we found a negative effect between extrinsic motivation and academic performance ($\gamma = -0.21$), implying that the more students resorted to intrinsic motivation, the weaker their academic performance.

5.1. Comparison between groups

We tested four hypotheses. Using the final total group parameters, we evaluated whether the direct effects of identified parameters in each group differed significantly from 0, according to the t -values. We also used the χ^2 difference to evaluate whether the strength of the parameter estimates differed in the experimental and control groups, by comparing the fit of an unconstrained two-sample path model with a constrained path model. To test whether the indirect effects of specified parameters in the groups differed significantly from 0, we used the χ^2 difference as well. That is, we tested whether the change in χ^2 compared with the change in degrees of freedom between the unconstrained and the constrained models was significant (Jöreskog and Sörbom 1993), by deducting the χ^2 and the degrees of freedom for the unconstrained model from those for the constrained model. If the χ^2 difference value was significant, the parameters in question differed significantly from 0. When this happened, we also evaluated the strength of the parameter estimates.

As we show in Figure 3, we found definite effects in the experimental and control groups. However, we cannot confirm whether these effects characterise both groups or only the experimental group. Figure 4 offers a clear representation of the effects.

In H1, we expected a significant positive direct effect of peer learning on academic performance in the experimental group but not in the control group. Therefore, we set the path coefficients of the parameters (peer learning and academic performance) free in both groups. The effect of peer learning on academic performance in the control group differed significantly from 0 ($t = 3.08$), so there was some effect of peer learning on academic performance in the control group. A further investigation, in which we tested the strength of the identified paths in both groups, set the identified coefficient parameters of the unconstrained model free. The χ^2 difference test showed an insignificant value (.2, $df = 1$), such that the identified indirect paths did not differ significantly in strength across experimental and control groups. Rather, peer learning had a direct effect on academic performance in the control group too.

We anticipated a significant, positive, indirect effect of peer learning on academic performance through intrinsic motivation in the experimental group; we did not expect this effect in the control group. We fixed the indirect path of the identified coefficient parameters in the constrained model and set them free in the unconstrained model; the χ^2 difference test

Figure 3. Structural model with significant standardised relationships.
Note: Paths denoted by dotted lines indicate negative relationships.

Figure 4. Direct and indirect effects between experimental and control groups.
Notes: Bold lines (straight and dashed) represent the experimental group; faint/light lines (straight and dashed) represent the control group. The dashed lines (bold and faint) indicate indirect effects, whereas the straight (bold and faint) lines indicate the direct effects.

revealed an insignificant value (3.77, $df = 2$). That is, the indirect effect of peer learning on academic performance through intrinsic motivation was not present in the control group (Figure 4).

We also predicted a significant, positive, indirect effect of peer learning on academic performance through deep learning, but only in the experimental group. The χ^2 difference test revealed a significant value ($p \leq 0.004$), so the indirect effect of peer learning on academic performance through deep learning emerged in the control group too (see Figure 4). In evaluating the strength of the identified paths, we found non-significant χ^2 difference test results (.12, $df = 2$). The strength of the identified paths was approximately the same in the experimental and control groups; we thus conclude that the indirect path exerted an impact on the control group.

Finally, we predicted a significant, positive, direct effect of help seeking on academic performance in the experimental group. The path coefficients of help seeking and academic performance were set free in both groups. As indicated in Figure 4, the result confirmed that the effect of help seeking on academic performance in the control group did not differ significantly from 0 ($t = -0.22$). Therefore, we conclude that there is no effect of help seeking on academic performance in the control group.

6. Discussion and conclusions

Cooperative, group-project learning is an interactive engagement approach that lecturers can use to achieve learning outcomes. We enhanced this method with technology, to determine if additional positive effects might arise from this integration. Initially, our intention was to use Blackboard's learning management system as a communication tool, but mobile phones appeared to provide a preferred, faster mode of communication. Therefore, we adjusted and created a discussion forum on Facebook so that students could easily access discussions through their mobile phones. Our goal was to answer a key question: How can TECGPL improve students' learning and performance? In line with Cheong's (2010) recommendations, we designed our group project to replicate industry-like group work in the learning environment. Thus, we sought to help students understand how the structure of material changes, due to heat, by using technology appropriately.

The significant positive relationship between deep learning and academic performance in the final model represents perhaps the most exciting result of this study, because it is in line with our theoretical notion, namely that TECGPL improves students' deep learning. With this method, students discuss content in groups and construct their own understanding, which leads to improved academic performance. Another significant result stems from the stronger indirect effect of peer learning on academic performance, compared with intrinsic motivation. Deep learning thus serves a significant function in the learning process (Floyd, Harrington, and Santiago 2009; Tarabashkina and Lietz 2011).

Some students learn best from one another (McKeachie 2002); determined students go the extra mile to improve their academic performance. For example, during personal conversation with students, some determined members of the control group indicated that they formed study groups with peers, on their own volition and without the knowledge of the lecturer. Not all students had opportunities to benefit from informal peer study groups though, because some students did not consider such initiatives helpful (Boud, Cohen, and Sampson 1999). Regardless of formal or informal settings though, peer learning contributed positively to students' performance (Kamps et al. 1994; Topping 2005).

Students in the experimental setting worked in groups, so they had to consult with their teammates. In contrast, students in the control group worked as individuals, and those who needed help might have avoided asking their peers, worried that it might signal their lack of capabilities (Kitsantas and Chow 2007). Students who seek help tend to be more motivated (Karabenick 2003); thus, they regard help seeking as a positive way to work towards learning goals. Such students show mature, intentional behaviour, and autonomy in finding solutions to their problems, by seeking help from lecturers and peers (Newman 2000). Figure 3 confirms this claim: the experimental group was more motivated than the control group and thus scored higher on help seeking.

The outcomes of this study are relevant to education in general; especially higher education institutions in that, lecturers must prepare students for the outside world. The notion of incorporating technology in cooperative learning is critical, because technology appears in almost

every field of modern work (e.g. communication, production). It also has affected communication strategies in education, altering the way lecturers teach and students learn. Virtually every sphere of education has its own relevant technology to support course designs; accordingly, lecturers must take responsibility to select the right technology for their courses and ensure that this chosen technology actually contributes to students' learning. Even though we cannot claim that the positive effects in this study come from technology or cooperative learning (group work), we believe that there is a possibility that both technology and cooperative learning complemented each other in the drive to develop students' real-life skills, which should enhance their well-being as students and in their future lives.

There also are several limitations to this study. First, unlike in other courses, where students have a choice to not attend class and request lecture notes from peers, students in this course had to be present in the classroom for their group performance to succeed. It was not always easy for group members to take on two roles if one member of the group was absent, especially in relation to report writing. Second, students considered WhatsApp and BBM easier and faster communication tools, but these channels made it difficult to track communication among participants, in that we lacked automatic access to their discussions, as was available on Facebook and Blackboard. To ensure that participants were discussing the content, we checked the discussion threads of each participant at the beginning of the experiment, which was time-consuming. As the project continued, participants realised that we could review their discussions at any time. Still, we had no guarantee that they were completely adhering to the established rules of communication. Third, the experimental group had an advantage of working in groups and using the discussion forums in Blackboard and in Facebook as well. Despite the fact that the control group had informally discussed the project outside the classroom, they might have missed some information posted on Blackboard and Facebook. As a result, this might have to some extent influenced the direct effect of peer learning on academic performance, as shown in Figure 4.

Even with these limitations, this study contributes to current understanding of the effectiveness of TECGPL methods. We demonstrate the importance of both direct and indirect effects of peer learning for attaining comprehension and academic performance. This study, performed in a higher education setting in South Africa, also represents a setting that has rarely been explored in prior research; the results should have implications for broader higher education settings as well. In particular, it emphasises the promise of TECGPL for exerting positive effects on students' learning and academic performance.

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About the authors

Malefyane Tlhoale is an instructional designer at the Tshwane University of Technology, South Africa. Her research focuses on interactive engagement methods, e-assessment in higher education, and technology-enhanced teaching and learning.

Cor Suhre is a senior researcher at University of Groningen in The Netherlands. His research focuses on curriculum design and improvement of student learning in Higher education.

Adriaan Hofman is professor of Education studies at University of Groningen and Erasmus University Rotterdam in The Netherlands. His research focuses on School and Teacher Effectiveness, Higher Education, Research Methods, and Education in Developing Countries.

Appendix

Part A. The following questions request demographic information. Please answer as accurately as possible. Circle the number which describes you well.

Gender:

- 1 Male
- 2 Female

Part B. The following questions are about your motivation and your attitudes to this subject. Indicate your level of agreement with the following statements by placing an 'X' in the appropriate number. For example, if you think the statement is 'very true of you', then place an X in '7'; if a statement is 'not at all true of you', place an X in '1'. If the statement is more or less true of you, find the number between 1 and 7 that best describes you.

<i>1 = Not at all true of me 7 = very true of me</i>							
Intrinsic Motivation							
1. I prefer activities that are challenging so that I can learn new things.	1	2	3	4	5	6	7
2. The course material is useful for me to learn.	1	2	3	4	5	6	7
3. I want to understand course content as thoroughly as possible.	1	2	3	4	5	6	7
4. I choose course assignment that I can learn from even if they don't guarantee a good grade.	1	2	3	4	5	6	7
Extrinsic Motivation							
5. Getting a good grade in this class is the most satisfying thing for me right now.	1	2	3	4	5	6	7
6. The most important thing for me right now is improving my overall grade point average. So my main concern in this class is getting a good grade.	1	2	3	4	5	6	7
7. If I can, I want to get Better Grades in this class than most of the other students.	1	2	3	4	5	6	7
8. I want to do well in this class because it is important to show my ability to my family and friends.	1	2	3	4	5	6	7
Peer Learning							
9. When studying for this course, I often try to explain the material to a classmate or a friend..	1	2	3	4	5	6	7
10. I try to work with other students from this class to complete the course assignments.	1	2	3	4	5	6	7
11. When studying for this course, I often set aside time to discuss the course material with a group of students from the class.	1	2	3	4	5	6	7
Help Seeking							
12. Even if I have trouble learning the material in this class, I try to do the work on my own without help from anyone.	1	2	3	4	5	6	7
13. I ask the instructor to clarify concepts I don't understand well.	1	2	3	4	5	6	7
14. When I can't understand the material in this course, I ask another student in this class for help.	1	2	3	4	5	6	7
15. I try to identify students in this class whom I can ask for help if necessary.	1	2	3	4	5	6	7

Part C. Please indicate your level of agreement with the following statements by placing an 'X' in the appropriate number. Remember there is no right or wrong answer – please answer as accurately as possible.

Cooperative group-project learning

	<i>Completely disagree</i>	<i>Slightly disagree</i>	<i>Agree</i>	<i>Slightly agree</i>	<i>Completely agree</i>
16. Cooperative group-project learning encourages sharing of knowledge and experience with other students.	1	2	3	4	5
17. Cooperative group-project learning improves communication skills, interpersonal skills and reduces competition.	1	2	3	4	5
18. Cooperative group-project learning helps to be more interactive during the learning process.	1	2	3	4	5
19. Cooperative group-project learning improves critical thinking as compared to lecture method.	1	2	3	4	5
20. Cooperative group-project learning is a good method for promoting students' understanding of course material.	1	2	3	4	5

Deep learning

	<i>Completely disagree</i>	<i>Slightly disagree</i>	<i>Slightly disagree</i>	<i>Slightly agree</i>	<i>Completely agree</i>
21. I find that at times studying gives me a feeling of deep personal satisfaction.	1	2	3	4	5
22. I find that I have to do enough work on a topic so that I can form my own conclusions before I am satisfied.	1	2	3	4	5
23. I feel that virtually any topic can be highly interesting once I get into it.	1	2	3	4	5
24. I find most new topics interesting and often spend extra time trying to obtain more information about them.	1	2	3	4	5
25. I test myself on important topics until I understand them completely.	1	2	3	4	5

Surface learning

	<i>Completely disagree</i>	<i>Slightly disagree</i>	<i>Slightly disagree</i>	<i>Slightly agree</i>	<i>Completely agree</i>
26. I learn some things by rote, going over and over them until I know them by heart even if I do not understand them.	1	2	3	4	5
27. I find I can get by in most assessments by memorising key sections rather than trying to understand them.	1	2	3	4	5
28. I find it not helpful to study topics in depth. It confuses and wastes time, when all you need is a passing acquaintance with topics.	1	2	3	4	5
29. I see no point in learning material which is not likely to be in the examination.	1	2	3	4	5
30. I find the best way to pass examinations is to try to remember answers to likely questions.	1	2	3	4	5