Chapter 5

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

Abstract

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 modeling, reveal that technology-enhanced, cooperative, group-project learning improves students’ comprehension and performance.

This chapter is based on:
Tlhoaele, M., Suhre C., & Hofman, A. Using technology-enhanced, cooperative, group-project learning for student comprehension and academic performance. Manuscript corrected and re-submitted for publication.
Using technology-enhanced, cooperative, group-project learning

5.1 Introduction

Business firms already have moved toward 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, 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 program 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 technology-enhanced, cooperative, group-project learning improve students’ comprehension and performance, and if so, how?

Cooperative learning refers to an instructional strategy in which students actively work together in small groups to enhance learning (Abrami, Poulsen, & Chambers, 2004), improve motivation, increase their understanding of course concepts, and improve their academic performance (Felder & Brent, 1994; Parrenas & Parrenas, 1993). However, to achieve the above, Fernandes, Mesquita, Flores and Lima (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 & 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, & 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.

5.2 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 & Kocevar-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 Kocevar-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.
5.3 Conceptual framework

We present our conceptual model in Figure 5.1 to detail the relationships among the variables in our study. The conceptual model indicates that peer learning could directly influence intrinsic motivation, 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, 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.

5.3.1 Peer learning

Some students learn best when they share ideas and learn from one another (Cooperstein & Kocevar-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, & Sampson, 1999). Peer learning encourages interdependent, as opposed to independent, learning (Keppell, Au, Ma, & Chan, 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.
5.3.2 Intrinsic motivation
Intrinsic motivation exists when the behavior 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 & 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.

5.3.3 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, & 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.
5.3.4 Help seeking

Previous research on help seeking largely focuses on psychological issues (Ayele, 2011; Biddle, Gunnel, Sharp, & Donavan, 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.

5.3.5 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 willingness that reflects an inner acceptance of the value of the task" (Ryan & Deci, 2000, p. 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 & Säljö, 2005), such that their academic performance becomes unsatisfactory.

5.3.6 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.

5.4 Method
5.4.1 Context and participants
One hundred and eighteen engineering students 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.
5.4.2 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 5.1). These questionnaires included some of the motivated strategies for learning questionnaire (MLSQ) items developed by (Pintrich, Smith, Garcia, & McKeachie, 1991). We used the revised two-factor study process questionnaire (R-SPQ-2F; (Biggs, Kember, & 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 .73 and .77, respectively (Table 5.1). The reliability of the variables varied from .73 to .87.
Table 5.1: Description, mean, standard deviations and reliabilities of variables in the study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>No. items</th>
<th>Pre-mean</th>
<th>SD</th>
<th>Post-mean</th>
<th>SD</th>
<th>α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peer learning</td>
<td>'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)</td>
<td>3</td>
<td>10.28</td>
<td>1.816</td>
<td>11.48</td>
<td>1.632</td>
<td>.87</td>
</tr>
<tr>
<td>Intrinsic motivation</td>
<td>‘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)</td>
<td>4</td>
<td>14.16</td>
<td>1.917</td>
<td>15.91</td>
<td>1.240</td>
<td>.76</td>
</tr>
<tr>
<td>Extrinsic motivation</td>
<td>‘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)</td>
<td>4</td>
<td>14.82</td>
<td>1.893</td>
<td>13.41</td>
<td>2.292</td>
<td>.82</td>
</tr>
<tr>
<td>Help Seeking</td>
<td>‘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)</td>
<td>4</td>
<td>14.88</td>
<td>1.873</td>
<td>16.37</td>
<td>1.938</td>
<td>.84</td>
</tr>
<tr>
<td>Deep learning</td>
<td>‘I treat the course material as a starting point and try to develop my own ideas about it’ (1 = this item is never or only rarely true of me, 5 = this item is always or almost always true of me)</td>
<td>5</td>
<td>18.06</td>
<td>2.936</td>
<td>19.81</td>
<td>1.608</td>
<td>.73</td>
</tr>
<tr>
<td>Surface learning</td>
<td>‘I see no point in learning material which is not likely to be in the examination’ (1 = this item is never or only rarely true of me, 5 = this item is always or almost always true of me)</td>
<td>5</td>
<td>21.58</td>
<td>2.044</td>
<td>16.77</td>
<td>2.391</td>
<td>.77</td>
</tr>
</tbody>
</table>
5.4.3 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 pretest to both groups. A day before the test, questionnaires were distributed to the students to complete.

5.4.4 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 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, 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 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 5.2a 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 5.2b 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.

5.4.5 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.
5.5 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 & 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, & 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, & Sugawara, 1996). The SRMR scores range from 0 to 1.0, and well-fitting models achieve scores less than .05 (Diamantopoulos & 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 & Bentler, 1999).

5.6 Results

We began with a significant test for the difference between the experimental and control groups. The ANOVA results revealed a significant difference ($F(1,116) = 73.51$, $p < .000$), whereas prior to the experiment, this difference was not significant ($F(1,116) = .002$, ns).

We present the mean scores and standard deviations in Table 5.2.

Table 5.2: The mean and the standard deviation of the pre- and the post tests for the two groups

<table>
<thead>
<tr>
<th>Group</th>
<th>$N$</th>
<th>Pre-mean</th>
<th>$SD$</th>
<th>Post-mean</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>59</td>
<td>51.97</td>
<td>5.76</td>
<td>68.76</td>
<td>9.65</td>
</tr>
<tr>
<td>Control</td>
<td>59</td>
<td>52.02</td>
<td>5.73</td>
<td>55.10</td>
<td>7.53</td>
</tr>
</tbody>
</table>
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The t-test results (Table 5.3) 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 5.3.

Table 5.3: Descriptive statistics of key variables in the study for both groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Post mean</td>
<td>SD</td>
</tr>
<tr>
<td>Intrinsic motivation</td>
<td>16.31</td>
<td>1.33</td>
</tr>
<tr>
<td>Extrinsic motivation</td>
<td>12.14</td>
<td>1.98</td>
</tr>
<tr>
<td>Peer learning</td>
<td>11.88</td>
<td>1.64</td>
</tr>
<tr>
<td>Help seeking</td>
<td>16.85</td>
<td>2.12</td>
</tr>
<tr>
<td>Deep learning</td>
<td>20.61</td>
<td>1.49</td>
</tr>
<tr>
<td>Surface learning</td>
<td>16.85</td>
<td>2.43</td>
</tr>
</tbody>
</table>

Next, we present the SEM results, starting with the outcomes of the general model, followed by the comparison between groups. According to the cut-offs discussed in the analysis strategy, the proposed model does not achieve satisfactory fit ($\chi^2 = 24.77$, df = 8, RMSEA = .13, SRMR = .08, and CFI = .95). To improve the fit, we removed the non-significant relationships such as gender and surface learning. The final model (Figure 5.3) indicated acceptable fit: $\chi^2 = 11.91$, df = 8, RMSEA = .06, SRMR = .05, and CFI = .99.
Peer learning emerged as the factor in the final model with the strongest impact. The direct effect of peer learning on intrinsic motivation \((\beta = .41)\) exerted the strongest effect in the model, followed by a direct effect of peer learning on deep learning \((\beta = .38)\). Peer learning also had a moderate direct effect on academic performance \((\gamma = .26)\). The relationship between deep learning and academic performance was the third strongest direct effect \((\beta = .33)\) in the final model. In addition, the indirect effect of peer learning on academic performance through deep learning \((\gamma = .13)\) was stronger than the indirect effect through intrinsic motivation \((\gamma = .10)\). The least strong but still significant \((p < .01)\) direct effect appeared between help seeking and academic performance \((\gamma = .13)\).

In line with our theoretical reasoning, extrinsic motivation correlated negatively with intrinsic motivation \((\gamma = -.28)\). The effect of extrinsic motivation on deep learning did not fit our predictions though; the results revealed a weak negative effect \((\gamma = -.16)\). Furthermore, we found a negative effect between extrinsic motivation and academic performance \((\gamma = -.21)\), implying that the more students resorted to extrinsic motivation, the weaker their academic performance.
5.6.1 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 $\chi^2$ 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 $\chi^2$ difference as well. That is, we tested whether the change in $\chi^2$ compared with the change in degrees of freedom between the unconstrained and the constrained models was significant (Jöreskog & Sörbom, 1993), by deducting the $\chi^2$ and the degrees of freedom for the unconstrained model from those for the constrained model. If the $\chi^2$ 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 5.3, 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 5.4 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 $\chi^2$ 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 $\chi^2$ difference test 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 5.4).

We also predicted a significant, positive, indirect effect of peer learning on academic performance through deep learning, but only in the experimental group. The $\chi^2$ difference test revealed a significant value ($p \leq .004$), so the indirect effect of peer learning on academic performance through deep learning emerged in the control group too (see Figure 5.4). In evaluating the strength of the identified paths, we found non-significant $\chi^2$ 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 in 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 5.4, 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.

5.7 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 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, & Santiago, 2009; Tarbashkina & 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 et al., 1999). Regardless of formal or informal settings though, peer learning contributed positively to students’ performance (Kamps, Barbeta, Leonard, & Delquadri, 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 & Chow, 2007). Students who seek help tend to be more motivated (Karabenick 2003); thus, they regard help seeking as a positive way to work toward learning goals. Such students show mature, intentional behavior and autonomy in finding solutions to their problems, by seeking help from lecturers and peers (Newman, 2000). Table 5.3 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 both technology and cooperative learning complemented each other in the drive to develop
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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 realized 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 5.4.

Even with these limitations, this study contributes to current understanding of the effectiveness of technology-enhanced, cooperative, group-project learning (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 emphasizes the promise of TECGPL for exerting positive effects on students’ learning and academic performance.