Student outcomes in the Twente education model
Research at the University of Twente

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Preface

Before you lies the research paper "Student outcomes in the Twente education model". This research has been conducted at the University of Twente for as part of my graduation from the study of Onderwijskunde (OWK). From August 2014 until August 2015 I have been analyzing data and writing the research paper.

The assignment for this research paper came from Rike Bron, PhD candidate at the University of Twente. She has guided me through all the processes of writing a research paper and has provided all the help and feedback necessary to bring this research paper to a successful end. Also, Maaike Endedijk has provided useful feedback and insights for improving my paper.

Hereby I want to thank them both for all their time, effort and support during the process of writing my research paper. Also, I want to thank all students that filled in the questionnaire. Without them I could have not conducted my research.

I wish you all a pleasant read,

Shanna Jansen van Jorksveld

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Abstract

The traditional education usually falls short on the aspects of learning and acquiring knowledge about communication, problem solving, positive attitudes and behaviours, adaptability and working with others. Project and problem based learning models have been designed to target these specific needs that are required in the work field.The question under investigation in this research is which processing and regulation strategies are most successful for higher learning outcomes in a project course within project and problem based learning in a TOM-module at the University of Twente? Students, first and second years, of various studies at the University of Twente were asked to fill out a questionnaire about their processing strategies, regulation strategies and motivation. Background variables such as age, gender, study year and self-efficacy were also collected in this questionnaire. These variables will be used to see which of them have an explanatory value on the learning outcomes. The learning outcomes of project problem based education are skills which students need to attain and use. The learning outcomes will be measured with project grades of students in this research. A factor analysis has been conducted to check the validity of the data. Next a correlation analysis and multiple regression analyses have been done to analyze the influence of the processing strategies, regulation strategies and motivation on the learning outcomes. The analyses showed that only processing strategies have a significant influence on the learning outcomes and other strategies, which were expected to have a positive influence, were not significant.

Introduction

Jobs nowadays require creative problem-solvers, who have the ability to work in teams and critically analyse their actions (Hogue, Kapralos, & Desjardins, 2011). The division between the industry and the university becomes smaller and universities strive to provide their students with education that gives them an advantage with regards to job requirements (Kek & Huijser, 2011). The traditional education usually falls short on the aspects of learning and acquiring knowledge about communication, problem solving, positive attitudes and behaviours, adaptability, working with others, and science, technology and mathematical skills (Hogue et al., 2011). Project and problem based learning models have been designed to target these specific needs that are required in the work field (Hogue et al., 2011). The emphasis of project and problem based learning lies on the active, transferable knowledge (Hmelo-Silver, 2004). This type of knowledge is what is expected of freshly graduates in the work field.

One of these project and problem based learning models is the Twente Education Model (TOM) at the University of Twente, Enschede. The University of Twente has mainly technical studies. TOM focuses on connecting theoretical courses with project courses. During these project courses, students work on a problem or assignment in project groups. The skills, which are required from freshly graduates, can be connected to learning strategies. A processing strategy is the way in which a student processes information. Some students will do this step by step; others will search for concrete examples in information. A regulation strategy can be used to control the processing of information. Choosing a strategy is a high order process connected with determining and choosing the right process to attack the problem a student is provided with. Motivation can have a intrinsic or extrinsic form, a will to study or having to study. Students might also have a feeling of demotivation, which withholds students from studying. Learning activities can be used by students to reach learning outcomes. These learning outcomes are expressed in grades, and are a reflection of the attainment of the skills of critical thinking, problem-solving, critical self-reflection and communication.

The expectation is that a combination of various learning activities will be most successful in project and problem based learning. Thus will lead to a higher learning outcome, which is a higher grade for the project course. The question which will be explored and analyzed will be; which processing and regulation strategies are most successful for higher learning outcomes in a project course within project and problem based learning in a TOM-module at the University of Twente?

Theoretical framework

What is project and problem based learning (PPBL)?

In the literature there is distinction between project based education and problem based education. According to Hmelo-Silver (2004) project based learning has students engage in scientific inquiry cycles as they design experiments, make predictions, conduct observations and construct explanations. Students work together in small groups and the problems they work on originate from professional practice. In problem based learning students use realistic, ill-structured problems to conduct their learning. The problem is central for attaining knowledge and applying reasoning strategies. Students build on their prior knowledge and attain new knowledge by going looking for the information they need to solve the problem (Hmelo-Silver, 2004).\Project based education and problem based education have similarities and overlap in some ways. Within project based learning and problem based learning students are responsible for their own learning, while they work on attaining skills such as critical thinking and problem solving. The cognitive principle of active learning prepares students to become lifelong learners, who acquire knowledge more rapidly than others (Burris & Garton, 2007; Hmelo-Silver, 2004). Project and problem based learning will also prepare students to have an extensive and flexible knowledge base (Burris & Garton, 2007; Hmelo-Silver, 2004). Also, while solving the problems they are presented with, students learn their domain-specific knowledge (Kek & Huijser, 2011).

Learning activities

Student learning is often investigated by looking into students' approaches to learning. An approach to learning is a combination of the intention of a student when starting a task, the learning process and strategies used to carry out a task. Baeten, Kyndt, Struyven, and Dochy (2010) distinguish four approaches to learning, each consisting of a set of related intentions, motives and learning processes.

A processing strategy is the way in which a student processes information. Some students will do this step by step; others will search for concrete examples in information. In the processing strategy students might also look for connection in their prior knowledge to which new knowledge can be linked. Student learning is a flexible process; students can use one approach in a typical context and another approach when the context is different.

A regulation strategy can be used to control the processing of information. Choosing a strategy is a high order process connected with determining and choosing the right process to attack the problem a student is provided with. To reflect on the process which has been chosen, students can improve their learning on the long term. Self-management, external regulation and no regulation are the three types of regulation strategies. Self-management means that the student takes own control over the learning. External regulation means that the control comes from the environment. The last type, no regulation, shows a lack of regulation or control over the learning process (Evans & Vermunt, 2013). In project and problem based learning, lectures provide students with guidance and structure they need to feel competent in handling learning material. A learning environment can be counterproductive if the teacher does not support autonomous learning (Baeten, Dochy, & Struyven, 2013a). Especially beginning students need guidance and direct instruction to grow accustom with self-management, for example in providing information and explaining contexts, because of their lack of long-term knowledge and schemas to integrate new knowledge with prior knowledge.

Baeten et al. (2013a) make a distinction between autonomous motivation and controlled motivation. Autonomous motivation involves that students experience a will and choice for learning, for example doing an activity for interest and enjoyment. Controlled motivation tends to pressure students to learn, for example being rewarded or praised for conducting an activity (Baeten et al., 2013a). Students might also experience demotivation; this can be caused by factors such as a lack of interest in the contents or no proper guidance.

Outcomes of project problem based learning

The outcomes of the learning activities are the learning outcomes, in this case the skills which are often required from freshly graduates. The skills are, critical thinking, problem-solving, critical self-reflection and communication. The focus is on these four skills because in Burris and Garton (2007) is said that competencies such as critical thinking and problem solving are essential for high performing workplaces. It is no longer important to only possess information, but also understand and use it. Also, these skills overlap each other in some ways, critical self-reflection is a base for learning the skill of critical thinking (Kim, Hong, Bonk, & Lim, 2011). Also, communication is an aspect of collaborative learning, which is a key element in project and problem based learning. Following will be brief description of the four skills.

In Iwaoka, Li, and Rhee (2010) critical thinking is described as a mode of thinking, about any subject, content or problem, in which the person's thinking improves the quality of the cognition by using structures which are essential in thinking. This imposes an intellectual standard on the thinking. Burris and Garton (2007) describe the ability to think critically as a way to find meaning in the world in which we live. Critical thinking skills cannot only be taught, but can also be transferred outside of the domain or context in which they are learned. Together with problem-solving, critical thinking, or critical analysis, is seen as two fundamental skills that should be developed in undergraduate students in university (Karantzas et al., 2013). In addition, Kek and Huijser (2011) state that students of today lack independent thinking skills, critical thinking skills is a part of this. Advances in technology have made a wealth of information freely accessible. However, it is important to identify credible and reliable information from bad information. Critical thinking is a key factor in this process. Students are often highly skilled at multi-tasking and can handle a lot of information simultaneously, however critically assessing the information ask for a higher form of learning (Kek & Huijser, 2011).

The focus nowadays is on practicing problem solving on a large number of problems. Instruction and feedback were more important in the past than knowledge and cognitive strategies needed to solve a problem (Mettas & Constantinou, 2008). The skill of problem-solving includes the ability to apply appropriate metacognitive and reasoning strategies. These strategies include control one has over planning, monitoring and evaluating of problem solving (Hmelo-Silver, 2004). Within PPBL, planning and reasoning are important for students when trying to solve problems in front of them, or to bring a project to sufficient closure. There is also a demand from the industry for more employers with research skills and an analytical approach to problem solving. The fact that products need to be highly competitive and need to be produced faster, forces the companies to hire more researchers at any layer of the company (Friesel, 2013).

Metacognition is seen as the basis for critical self-reflection. When students know what they know, they can adapt learning approach. An effective metacognitive training is often linked with a constructivist learning environment, in which students take an active role in their own learning (Glava & Glava, 2011). Reflection is a key element for PPBL, because it can lead to a group learning environment. When implemented properly it can foster critical thinking and metacognitive reasoning (Kim et al., 2011).

Communication skills and collaborative learning are closely woven together. According to Notari, Baumgartner, and Herzog (2014) project and problem based learning is a typical variant of collaborative inquiry-based learning. In order to achieve collaborative learning, communication skills are needed. Working and practicing within teams or groups, communication skills are trained and collaborative learning can be achieved. According to Hmelo-Silver (2004), being a good collaborator is knowing how to function well as part of a team. Within PPBL, students learn to understand multiple perspectives. Special education students learn skills such as patience and empathy in PPBL (Notari et al., 2014). Included in this are tasks of establishing common ground, resolving discrepancies, negotiating actions that involve the whole team and coming to agreements. The processes of being a good collaborator and collaborative learning are woven together.

The present study

The most important learning activities within PPBL, when looking at the four skills, are: relate and structure, critical processing, analyze, self-management and a will to study. However, this does not mean that other learning activities are not successful. The expectation is that a combination of various learning activities, namely: relate and structure, critical processing, analyze, self-management and a will to study, will be most successful in project and problem based learning. Thus will lead to a higher learning outcome, which is a higher grade for the project course. Within project and problem based learning, this is expected to be the most successful approach to learning (Baeten et al., 2013a; Donche, Van Petegem, & Vermunt, 2010; Hmelo-Silver, 2004; Kek & Huijser, 2011). When these learning activities are done by students they will reach their learning outcomes with more success, or in other words, they will aim for the highest possible grade.

Method

The choice of the research design will be explained in the following paragraph. In this quantitative descriptive study, students of the University of Twente are used as respondents. The aim is to collect data about their use of processing and regulation strategies within project problem based education and collect their project grades. There are dependent and independent variables with an implied causal connection (Field, 2013). In this case, the strategies of the processing and regulation strategies are the independent variables, and the learning outcomes, which are quantified in the form of project grades, are the dependent variables.

Case selection and sampling

Students from the University of Twente, which is a university with mainly technical studies, are the respondents in this research. A non random sample from all of the students is used to collect data. These students were specifically chosen for this research because they just finished their modules which are project problem based orientated. The faculties the respondents attend are used in the data to guarantee their anonymity. Students from the fields of CTW (study year 1 and 2), BMS (study year 1) and TNW are asked to fill out the questionnaire. The first year students were included in the study because they just started learning through PPBL in TOM education at the University of Twente. The second year students from CTW were included to analyze if they are more accustom with learning within PPBL and attaining skills. In total 210 participants are included in the data set. The descriptives of the participants can be found in table 1.

The faculty of CTW, or engineering technical studies, houses three different bachelor studies and five master studies in the areas of civil engineering, industrial design and mechanical engineering. CTW has approximately 1800 students. The faculty of behavioral, management and social sciences (BMS) houses the fields of psychology, business studies, public administration, communication, philosophy, educational sciences and health sciences. The focus of this faculty is to address social issues. TNW, the faculty of technical physical sciences, houses five different bachelor studies and five master studies varying from chemical technology to technical medicine. The faculty has around 30 research teams working in the fields of nano technology, renewable energy and biomedical technology. During the rest of the research paper, the abbreviations of the faculties will be used.

Table 1

Descriptives of participants and response rate

Faculty	Study year	Participants	Age (mean)	Gender	Total students	Response	Percentage
CTW1	1	93	18,84	Male: 92,5% Female: 7,5%	131	93	71%
CTW2	2	30	19,79	Male: 93,3% Female: 6,7%	107	30	28%
BMS	1	26	19,15	Male: 38,5% Female: 61,5%	36	26	72%
TNW	1	61	18,92	Male: 49,2% Female: 50,8%	68	61	90%

Instruments

Processing strategies and regulation strategies

The processing and regulation strategies can also be found in the LEMO-questionnaire from Donche et al. (2010). The questionnaire is meant for students to gain feedback on their own way of learning and to access their learning styles. In this way students can analyze their strengths and weaknesses, and work on improvement. This questionnaire has been used to conduct the survey in the research. All questions and scales are valid and the scales of LEMO have a predictive validity (Donche et al., 2010). The questionnaire measures different processing strategies, regulation strategies, aspects of study motivation and self efficacy. The learning outcomes, which are quantified in the form of project grades, are the dependent variables. The questionnaire was filled in by students of the University of Twente and it was only filled in once, at the end of a module. The answers to the questionnaire provided information about many different variables. The independent variables from the processing and regulation strategy have been measured and the grades for the dependent learning outcomes are collected. Background variables such as gender, age, study year and *self-efficacy* were also collected.

The scales measured within the processing strategies are; *relate and structure* (RS), *critical processing* (CP), *analyze* (AN), *memorize* (ME), *concrete processing* (CoP). *Relate and structure* means that students can relate information and structure new information. *Critical processing* contains the idea that students can look at information with skepticism, where does information come from, is it reliable? The strategy of *analyze* helps students process the information they have in front of them. *Memorize* means that students can reproduce information. Last, *concrete processing* lets students process and think about what information is in front of them. The regulation strategies include the following scales: *self-management* (SM), *external regulation* (ER) and *no regulation* (NR). *Self-management* is the idea that students manage their learning on their own. *External regulation* means that their learning is controlled by an external drive. *No regulation* consists of aspects of no guidance or drive. Motivation makes a distinction between three scales: *will to study* (WS), *have to study* (HS) and *demotivation* (DM). *Will to study* means that students have an intrinsic drive to study, *have to study* means that students get the feeling to study externally. *Demotivation* consists of feelings of demotivation and lack of interests. Last, *self-efficacy* (SE) is also measured with the questionnaire. Within this study, *self-efficacy* has been used as a background variable. Throughout this research, the abbreviations for each scale might be used in tables and text.

The questionnaire has 53 questions with a five level Likert-scale based answering method. The distribution and the measurement of the scores is explained in Donche et al. (2010).

Factor and reliability analysis

A factor analysis was done per strategy (processing strategy, regulation strategy, motivation and *self-efficacy*). A principal components analysis was conducted with direct oblimin on the items which are part of each strategy.

First the processing strategy has been analyzed, which consisted of a total of 20 items to begin with, in five different components (Donche et al., 2010)Donche et al., 2010). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO =.730. According to Field (2013) this is scored as "good". The factor analyses has been several times, this did not result in the original factors. So, the decision has been made to leave out several items. The components are *relate and structure*, *critical processing*, *analyze*, *memorize* and *concrete processing*. The components of *relate and structure* and *critical processing* will be used as one component from now on. According to Iwaoka et al. (2010), *critical processing* will lead to better thinking and reasoning, achieved through *relating and structuring* information, is mentioned as one of the foundations for *critical processing*. Four items were eliminated from the data set because they would load on two or more components, with a low factor loading. Two items do not fit in with the general concept behind the associated scale. Eliminating these items also brought back the components from 7 to 4, with very clearly visible the different scales in the processing strategy. The scales turned out to be *relate and structure*/*critical processing*, *analyze*, *memorize* and *concrete processing*.

The regulation strategy was analyzed on the same way as the processing strategy. The strategy consists of 14 items to begin with, which are three different components within the LEMO-questionnaire (Donche et al., 2010). The Kaiser-Meyer-Olkin measure gives KMO = .675, which is mediocre according to Field (2013). Running the initial factor analysis came up with four components. When analyzing the pattern matrix it shows that one item has a large cross loading on all four components, with very low factor loading on all of them. When analyzing the contents of this item shows that the formulation is overly positive, this does not fit in with the items that also belong to this scale. This leads to the decision to eliminate this question. The second factor analysis gives three components with clearly visible the scales from the regulation strategy. The three components are *self-management*, *external regulation* and *no regulation*.

Motivation consists of three components according to Donche et al. (2010). The KMO = .789, which is labeled as "good" (Field, 2013). The first run gives four components and analysis of the pattern matrix shows one item with very low factor loadings on all components and another item as an almost separate component. The first item is formulated as if learning is an ultimate life goal, this might be a too extreme answer for students. The second item states that students are forced by their environment to study; the other items in the associated scale are milder in their formulation. A new analysis is run after eliminating these two items and it comes up with three components, *will to study*, *have to study* and *demotivation*.

Last is *self-efficacy*, which will be used as a background variable. When running the factor analysis, one component is given with KMO = .764, which is labeled as "good" (Field, 2013). The settings for the factor analysis are the same as with the other strategies. According to Donche et al. (2010) *self-efficacy* consists of one components. Nothing has to be done to alter the outcome of this strategy.

Reliability analyses have been conducted on the remaining questions. In table 3 the Cronbach's Alpha for each scale is given together with the correlations. The Cronbach's Alpha for the scale *analyze* is considered low (Field, 2013), however adding the deleted item only makes the Cronbach's Alpha lower. Also, the item-total statistics shows that the Cronbach's Alpha will not be higher if another item is deleted. The same goes for the scale of *concrete processing*. The scale of *external regulation* is also considered low, adding the deleted item shows the same Cronbach's Alpha. Also, deleting another item within the scale doesn't increase Cronbach's Alpha. Although some Cronbach's Alpha are considered low on some scales, the decision has been made to work with these scores. In Donche et al. (2010) the Cronbach's Alpha for each scale was sufficient ($\geq .69$), so the scales are considered reliable. Because of this fact, the decision was made to use the scales for further analyses despite the low Cronbach's Alpha on some of them.

Data and analysis

The following chapters describe the results of the conducted questionnaire. In the first part, descriptives of each module are given. The mean and standard deviation are most important to see if there a differences in the module and between the modules. In the second part a correlation table is given from all modules together with the project grade. Last, the multiple regression analyses are described. Three regression analyses are done, one for each strategy (processing, regulation and motivation) in combination with background variables (study year, gender and *self-efficacy*).

Descriptives of the means and standard deviations of the faculties

First the overall means and standard deviations will be discussed; next some notable means and standard deviations of each faculty will be analyzed.

As can be seen in table 2, the overall means don't vary much from the means for each faculty. The means for *external regulation* and *self-efficacy* are score high on the overall mean, as well as for the individual means for each faculty. *Demotivation* scores a low overall mean, as well as that the individual means score low. Notable is the high standard deviation on the scale *memorize*. BMS scores a lower standard deviation while CTW2 and TNW score much higher. Also, *have to study* scores a high standard deviation overall, while CTW scores a lower individual standard deviation.

Next the descriptives of BMS will be discussed. The scale of *external regulation* has, in comparison to the other scales, a higher mean with a lower than average standard deviation. When looking at the general concept of the scale, it shows that students learn as told by their teachers. *Will to study* also has, in comparison, a higher mean with a low standard deviation. The contents of the question show that students find studying fun and valuable. On the other hand, *demotivation* has very low mean, the score on this scale shows that students do know why they are studying and they see the meaning of their study. The students of CTW2 (year 2) also score low on *demotivation*, the low means tells that students see the point in studying. *External regulation* has a higher mean, in comparison to the other scales. Same as the students of BMS, whom are first year students, they follow the study material and use the instructions of teachers. Significance is the standard deviation of the scale *memorize*, this one is very high. This tells that student's answers diverge greatly on this scale. The first year CTW1 students also score a low *demotivation* mean, which tells us the students of CTW (year 1), see the point in studying. Last are the descriptives of TNW. Same as the other three groups of students, these students also score a low mean on *demotivation*. The standard deviations of *memorize* and *have to study* are high. The high standard deviation tells that the answers given by students are not in close range of each other.

When comparing the four modules with each other, the means of all scales do not vary a lot. When looking at the scales which are included in the hypothesis that will lead to higher learning outcomes, table 2 shows a few differences. The scale of *relate and structure*/*critical processing* shows comparable means and standard deviations for all four modules. *Analyze* also has comparable means, however, the standard deviations for CTW2 (year 2) and TNW are higher. This indicates that answers from these students vary more. The means of *self-management* are further apart for CTW2 (year 2) and TNW. The other two modules are in between these two means. *Will to study* scores the highest mean with BMS and *self-efficacy* scores highest with CTW2 (year 2). Notable are the scores of the means for *demotivation*, all modules score very low. This is positive because students do not feel *demotivation* during their module.

The values for the means and standard deviations discussed can be found in table 2.

Table 2

Descriptives of the modules

	BMS		CTW2 (year 2)		CTW1 (year 1)		TNW		Overall	
Scale	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Relate and structure/critical processing (RSCP)	3.02	.60	2.85	.65	3.13	.65	3.17	.54	3.08	.62
Analyze (AN)	2.77	.64	2.64	.86	2.80	.68	2.91	.81	2.80	.74
Memorize (ME)	3.12	.67	2.48	.99	2.46	.75	2.85	.93	2.66	.86
Concrete processing (CoP)	2.42	.57	2.68	.86	2.89	.76	2.95	.75	2.87	.75
Self-management (SM)	2.42	.51	2.14	.69	2.40	.81	2.70	.75	2.46	.76
External regulation (ER)	3.62	.41	3.67	.53	3.50	.61	3.46	.59	3.53	.57
No regulation (NR)	2.72	.72	2.58	.77	2.63	.86	2.69	.71	2.65	.79
Have to study (HS)	2.94	.76	3.08	.68	2.63	.80	2.83	.90	2.79	.82
Will to study (WS)	3.94	.43	3.64	.56	3.59	.65	3.83	.80	3.71	.67
Demotivation (NM)	1.47	.62	1.31	.43	1.65	.79	1.47	.57	1.53	.68
Self-efficacy (SE)	3.44	.46	3.68	.63	3.33	.84	3.45	.88	3.42	.79

Correlations and multiple regression analyses

In the second part of the result a correlation table is given and discussed. The expectation is that there will be a positive correlation of *relate and structure*/*critical processing*, *analyze*, *self-management* and a *will to study* on the learning outcomes, which is the project grade. Next, three different multiple regression analyses are done. Processing strategy, regulation strategy and motivation are the three different multiple regression analyses. They are analyzed in combination with the background variables of study year, gender and *self-efficacy*.

Correlations

Table 3 shows the correlations between the scales and background variables in combination with, if applicable, the Cronbach's Alpha. According to Field (2013) a Pearson correlation is a small effect when r= ± 0.1, a medium effect when r= ± 0.3 and a large effect when r= ± .5. When the number is positive, this indicates a positive relationship. When the number is negative, this shows a negative relationship. The principal correlations which have to be looked at are the scales from the hypothesis and project grade. There was a negligible relationship between the two variables *relate and structure*/*critical processing* and project grade, r= .08. The same goes for *analyze* (r= .02), *self-management* (r= .03) and *will to study* (r= -.04). However, there is a low positive relationship between the two variables *self-efficacy* and project grade, r= .21.

Although the scales from the main hypothesis show no correlations worth mentioning besides *self-efficacy*, other Pearson's correlations are worth mentioning.

First the processing strategies and their correlations will be discussed. There was a strong positive relationship between the two variables of *relate and structure*/*critical processing* and *self-management*, r= .50. Also, the moderate positive relationship between the variables *relate and structure*/*critical processing* and *concrete processing* is worth mentioning, r= .38. In addition, *relate and structure/critical processing* shows a small effect with *have to study*, r= .22 and with *analyze*, r=.25. These four correlations are significant at $p \leq 0.01$. The scale *analyze* shows a small effect with *memorize* (r=.26, $p \leq 0.01$), *concrete processing* (r=.16, $p \leq 0.05$), *self-management* (r=.20, $p \leq 0.01$) and with *will to study* (r=.16, $p \leq 0.05$). Another processing strategy, *memorize*, shows a medium effect with *external regulation* (r=.33, $p \leq 0.01$). It also shows a small effect with *will to study* (r=.24, $p \leq 0.01$) and *demotivation* (r=16, $p \leq 0.05$). *Concrete processing* shows only one significant correlation with *self-management* (r=33, $p \leq 0.01$).

Second, the regulation strategies will be discussed. The scale of *self-management* also has a medium effect relationship with *have to study*, r= .33. This indicates that there is correlation between having to study and students being *will to study*. Also, *self-management* shows a small effect with *self-efficacy*, r=.25. Both of the correlations are significant at the $p \leq 0.01$ level. *External regulation* shows a small effect with *have to study* (r=.14, $p \leq 0.05$). The scale of *no regulation* has medium correlations with *demotivation* (r=0.32, $p \leq 0.01$) and *self-efficacy* (r= -.34, $p \leq 0.01$). Also, *no regulation* shows small effects with *will to study* (r=.19, $p \leq 0.05$), *have to study* (r=0.19, $p \leq 0.01$), and project grade (r=-.17, $p \leq 0.05$).

Last, the motivation strategies. *Will to study* shows a small effect with *no motivation* (r=.22, $p \leq 0.01$). *Have to study* shows medium effect with both *no motivation* (r= -.45, $p \leq 0.01$) and *self-efficacy* (r=.30, $p \leq 0.01$). Last, *no motivation* shows a small effect with *self-efficacy* (r= -.17, $p \leq 0.05$).

Table 3

Correlation table of scales and project grade

	Age	Gender	Study year	RSCP	AN	ME	CoP	SM	ER	NR	WS	HS	NM	SE	Project grade
Age	-														
Gender	-.08	-													
Study year	.35**	-.13	-												
RSCP	.03	.02	-.10	**.69**											
AN	.12	.06	-.14	.25**	**.52**										
ME	.02	.15*	-.09	.02	.26**	**.73**									
CoP	.09	-.02	-.05	.38**	.16*	-.03	**.49**								
SM	.01	.11	-.14	.50**	.20**	.11	.33**	**.63**							
ER	.05	.07	.14	.01	.10	.33**	.00	-.10	**.50**						
NR	.03	.01	-.03	.10	.05	.14	.13	.02	.01	**.70**					
WS	.02	.03	.10	-.07	.16*	.24**	.00	-.06	.12	.19*	**.73**				
HS	.10	.31**	-.03	.22**	.04	.04	.04	.33**	.14*	-.19**	-.13	**.82**			
NM	-.04	-.24**	-.16*	.05	.07	.16*	.08	-.03	-.07	.32**	.22**	-.45**	**.79**		
SE	-.14*	.11	-.03	.14	.07	.06	-.03	.25**	.08	-.34**	-.10	.30**	-.17*	**.86**	
Project grade	.03	.10	-.07	-.08	.02	-.06	.01	.03	.08	-.17*	-.04	.11	.01	.21**	-

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Note: the coefficients on the diagonal in bold are the Cronbach's Alpha for each scale.

Multiple regression analyses

Multiple regression analyses have been conducted to see if the different strategies and background variables predicted the learning outcomes of students. The background variables are age, gender, study year and *self-efficacy*. The project grade, which is a reflection of the learning outcomes, is the constant in all analyses. The enter method was used to add variables to the analysis.

For all regression analyses the same requirements are applicable. If the significance value is less than .05, the finding is statistically significant. The R square value tells how much of the variance in the analysis is explained by the various predictor values. The adjusted R square takes into account the number of variables involved. Additional variables will tent to increase the adjusted R square. If it decreases when another variable is added, this means that the new variable doesn't add explanatory power to the model. The beta tells if regression is positive or negative for this variable.

First the multiple regression analyses for processing strategies and the background variables (age, gender, study year and *self-efficacy*. The values of the multiple regression analysis can found in table 4. The analysis shows that the second model is significant ($p \leq .05$). Next the R square will tell how much of variance is explained by the associated variables. Using the enter method was found that *relate and structure/critical processing*, *analyze*, *concrete processing* and *memorize* explain a moderate significant amount of the project grade ($p \leq .05$, $R^2 = .105$, R^2 adjusted = .054). This tells that 10.5% of the project grade is predicted by the processing strategies, however to say which processing strategy has a positive influence on this prediction; the Beta values need to be analyzed. The P-values of the Beta values shows that only self-efficacy is significant in the second model, the processing strategies do not have any significance when looking at the beta and p-values.

Table 4

Multiple regression analysis predicting project grade with background variables and processing strategies

Model	R	R square	Adjusted R square	Beta	P-values	F	Significance
Project grade	.253	.064	.038		.044	2.426	.051
Age				.148	.113		
Gender				.046	.572		
Study year				-.112	.226		
Self-efficacy				.234	.006		
Project grade	.335	.105	.054		.078	2.032	.047
Age				.162	.086		
Gender				.071	.388		
Study year				-.150	.111		
Self-efficacy				.264	.002		
RSCP				-.163	.068		
AN				.073	.414		
CoP				-.156	.074		
ME				.068	.430		

Next the multiple regression analyses for regulation strategies and the background variables (age, gender, study year and *self-efficacy*. The values of the multiple regression analysis can found in table 5. The analysis shows that the second model is not significant ($p \geq .05$). When using the enter method, it was found that *self-management*, *external regulation* and *no regulation* explain a small amount of the project grade, and as said before, the model is not significant ($p \geq .05$, $R^2 = .086$, R^2 adjusted = .039). This tells that 8.6% of the project grade is predicted by regulation strategies. The Beta values need to be analyzed in order to see which regulation strategies have a positive influence on the project grade. The analysis shows that in the second model none of the Beta values are significant; all of them are $p \geq 0.05$. In the first model, only self-efficacy is significant (β=.237, p=.006).

Table 5

Multiple regression analysis predicting project grade with background variables and regulation strategies

Model	R	R square	Adjusted R square	Beta	P-values	F	Significance
Project grade	.252	.064	.037		.045	2.393	0.053
Age				.149	.111		
Gender				.034	.683		
Study year				-.118	.204		
Self-efficacy				.237	.006		
Project grade	.293	.086	.039		.057	1.849	0.083
Age				.168	.078		
Gender				.036	.665		
Study year				-.136	.159		
Self-efficacy				.187	.060		
SM				-.037	.685		
ER				.074	.382		
NR				-.137	.135		

Last the multiple regression analyses for motivation and the background variables (age, gender, study year and *self-efficacy*. The values of the multiple regression analysis can found in table 6. The analysis shows that the second model is not significant ($p \geq .05$). When using the enter method, it was found that *will to study*, *have to study* and *demotivation* explain a real small amount of the project grade, and as said before, the model is not significant ($p \geq .05$, $R^2 = .069$, R^2 adjusted = .021). This tells that 6.9% of the project grade is predicted motivation. The Beta values can tell which type of motivation has a positive influence on the project grade. The Beta and p values show that none of the motivation strategies are significant; all the p values are $p \geq 0.05$. In the second model, only self-efficacy is significant (β=.218, p=.018).

Table 6

Multiple regression analysis predicting project grade with background variables and motivation

Model	R	R square	Adjusted R square	Beta	P-values	F	Significance
Project grade	.240	.058	.031		.047	2.152	.078
Age				.116	.185		
Gender				.054	.519		
Study year				-.076	.377		
Self efficacy				.221	.009		
Project grade	.262	.069	.021		.020	1.452	.190
Age				.107	.238		
Gender				.055	.537		
Study year				-.066	.468		
Self-efficacy				.216	.018		
WS				.041	.643		
HS				.082	.420		
NM				.099	.307		

Conclusion

To recap, the research question is: which processing and regulation strategies are most successful for higher learning outcomes in a project course within project and problem based learning in a TOM-module at the University of Twente? In this research data has been collected among various studies at the University of Twente, first year and second year students have been included. The students were asked to fill out the LEMO-questionnaire from Donche et al. (2010). The questionnaire contains the concepts which are aimed to measure in this research, processing strategies, regulation strategies and motivation. The background variables which are included are age, gender, study year and *self-efficacy*. The different strategies and background variables are used to analyze how much influence they have on learning outcomes. The learning outcomes are skills students learn in project problem based education. Project grade is used as the quantifiable measure of the skills of critical thinking, problem solving, critical self-reflection and communication. The expectation was that a combination of various strategies, namely: *relate and structure*, *critical processing*, *analyze*, *self-management* and a *will to study*, would be most successful in project and problem based learning (Baeten et al., 2013a; Donche et al., 2010; Hmelo-Silver, 2004; Kek & Huijser, 2011).

The correlations told that the strategies from the hypothesis weren't high enough to be considered a medium or high effect on project grade (Field, 2013). Other correlation did show correlations worth mentioning. There was a high relationship between *relate and structure*/*critical processing* and *self-management*. This indicates that is of importance that when using this strategy, students self-manage their learning. Also, the moderate positive relationship between *self-management* and *have to study* is worth mentioning. This supports the idea of Baeten, Dochy, and Struyven (2013b) that students will learn better when their learning is also influenced by external drives. However, the two variables of *have to study* and *demotivation* showed a high negative relationship. This indicates that having to study is not influenced by any feelings of demotivation or students having no idea why they are studying.

The multiple regressions showed that self-efficacy has a significant influence on the project grade within the models of regulation strategies and motivation. *Relate and structure/critical processing* and *concrete processing* had a negative influence on the explanatory factor for project grade, although the influence was not significant. This contradicts with the hypothesis that *relate and structure/critical processing* would be successful in PPBL (Baeten et al., 2010). Although the model for regulation strategies was not significant, the Beta values did tell which strategies positively or negatively influence project grade. None of the Beta values for the regulation strategies were significant. According to Baeten et al. (2013b) a combination of *self-management* and *external regulation* is most successful within PPBL. Finding that neither *self-management* nor *external regulation* influences project grade does not underpins this hypothesis. Different strategies of motivation all had a positive Beta, however none of them were significant. The expectation was that the *will to study* strategy would influence project grade in a positive manner. *Self-management* is an important aspect of project problem based education (Hanney & Savin-Baden, 2013; Hmelo-Silver, 2004). However, the analyses showed that *self-management* had a negative influence on the learning outcome and the influence was not significant. According to Baeten et al. (2013b) a combination of *self-management* and *external regulation* is most successful within PPBL.

So, to answer the research question; which processing and regulation strategies are most successful for higher learning outcomes in a project course within project and problem based learning in a TOM-module at the University of Twente? The strategies that were in the hypothesis show not to be most successful within project problem based learning in a TOM-module at the University of Twente. Their influence on the project grades of students is not significant. The expectation from Baeten et al. (2013b) that *relate and structure/critical processing* would be successful is contradicted. There is no evidence found that these strategies are successful within a TOM-module at the University of Twente. Also, the claim that *self-management* is an important aspect within project problem based education can't be proven (Hanney & Savin-Baden, 2013; Hmelo-Silver, 2004). The only significant values found are for self-efficacy, which has been used as a background variable. This shows that the confidence students have in their own learning is of significance for a higher learning outcome. This leads to conclusion that none of the processing and regulation strategies can be labeled as most successful for a higher learning outcome within a project course in a TOM-module at the University of Twente.

Discussion

The research design and measurement have some limitations. According to (Baarda and Goede (2006)) it should have been desirable to have a bigger sample of respondents. Since the University of Twente has approximately 9000 students, the response of 210 students could have been higher. Also, the response rate from CTW (year 2) could have been higher. Due to time limitations, both the desirable bigger sample and the response rate are settled for. Also, some of the reliability tests are considered low (Field, 2013). Since adding already deleted items or removing other items was not an option, these reliability scores are settled for. Adding more respondents to the research might have also helped to increase the reliability scores. Also, the values found in the multiple regression analyses might have told more if more students were included in the research. In addition, the LEMO-questionnaire was used to collect data. Due to the low reliabilities, it might be recommended to develop an instrument which might be more appropriate to measure the strategies among students in project and problem based education. Each module has different goals and tries students to attain different skills. A more specific questionnaire might provide data which will give more insight in which strategies students for attaining a specific skill. In Donche et al. (2010) is stated that education is dynamic and constantly changes, so the LEMO-questionnaire also needs constant revising.

Further research into *self-management* and *external regulation* should look at the relationship between these two regulation strategies. Looking at why *self-management* is not working within these TOM-modules at the University of Twente and in which way can *external regulation* be used to increase the influence of *self-management*?

Bibliography

Baarda, D., & Goede, M. d. (2006). *Basisboek: handleiding voor het opzetten en uitvoeren van kwantitatief onderzoek-4e, geheel herz. dr*: Groningen [etc.]: Wolters-Noordhoff.

Baeten, M., Dochy, F., & Struyven, K. (2013a). The effects of different learning environments on students' motivation for learning and their achievement. *British Journal of Educational Psychology, 83*(3), 484-501. doi: 10.1111/j.2044-8279.2012.02076.x

Baeten, M., Dochy, F., & Struyven, K. (2013b). Enhancing students' approaches to learning: the added value of gradually implementing case-based learning. *European Journal of Psychology of Education, 28*(2), 315-336. doi: 10.1007/s10212-012-0116-7

Baeten, M., Kyndt, E., Struyven, K., & Dochy, F. (2010). Using student-centred learning environments to stimulate deep approaches to learning: Factors encouraging or discouraging their effectiveness. *Educational Research Review, 5*(3), 243-260. doi: 10.1016/j.edurev.2010.06.001

Burris, S., & Garton, B. L. (2007). Effect of Instructional Strategy on Critical Thinking and Content Knowledge: Using Problem-Based Learning in the Secondary Classroom. *Journal of Agricultural Education, 48*(1), 106-116.

Donche, V., Van Petegem, P., & Vermunt, J. (2010). De LEMO-Vragenlijst Deel 1. 14.

Evans, C., & Vermunt, J. D. (2013). Styles, approaches, and patterns in student learning. *British Journal of Educational Psychology, 83*(2), 185-195. doi: 10.1111/bjep.12017

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*: Sage.

Friesel, A. (2013). *Combining project based learning with exercises in problem solving in order to train analytical mathematical skills.* Paper presented at the Global Engineering Education Conference (EDUCON), 2013 IEEE.

Glava, C.-C., & Glava, A.-E. (2011). Development of metacognitive behavior of future teacher students through electronic learning diaries as means of self reflection. *World Conference on Information Technology (Wcit-2010), 3*. doi: 10.1016/j.procs.2010.12.108

Hanney, R., & Savin-Baden, M. (2013). The Problem of Projects: Understanding the Theoretical Underpinnings of Project-Led PBL. *London Review of Education, 11*(1), 7-19.

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235-266.

Hogue, A., Kapralos, B., & Desjardins, F. (2011). The Role of Project-Based Learning in IT: A Case Study in a Game Development and Entrepreneurship Program. *Interactive Technology and Smart Education, 8*(2), 120-134.

Iwaoka, W. T., Li, Y., & Rhee, W. Y. (2010). Measuring Gains in Critical Thinking in Food Science and Human Nutrition Courses: The Cornell Critical Thinking Test, Problem-Based Learning Activities, and Student Journal Entries. *Journal of Food Science Education, 9*(3), 68-75.

Karantzas, G. C., Avery, M. R., Macfarlane, S., Mussap, A., Tooley, G., Hazelwood, Z., & Fitness, J. (2013). Enhancing critical analysis and problem-solving skills in undergraduate psychology: An evaluation of a collaborative learning and problem-based learning approach. *Australian Journal of Psychology, 65*(1), 38-45. doi: 10.1111/ajpy.12009

Kek, M., & Huijser, H. (2011). The power of problem-based learning in developing critical thinking skills: preparing students for tomorrow's digital futures in today's classrooms. *Higher Education Research & Development, 30*(3), 329-341. doi: 10.1080/07294360.2010.501074

Kim, P., Hong, J.-S., Bonk, C., & Lim, G. (2011). Effects of group reflection variations in project-based learning integrated in a Web 2.0 learning space. *Interactive Learning Environments, 19*(4), 333-349. doi: 10.1080/10494820903210782

Mettas, A. C., & Constantinou, C. C. (2008). The Technology Fair: a project-based learning approach for enhancing problem solving skills and interest in design and technology education. *International Journal of Technology and Design Education, 18*(1), 79-100. doi: 10.1007/s10798-006-9011-3

Notari, M., Baumgartner, A., & Herzog, W. (2014). Social skills as predictors of communication, performance and quality of collaboration in project-based learning. *Journal of Computer Assisted Learning, 30*(2), 132-147. doi: 10.1111/jcal.12026