The Effects of LADs with Reference Frames on Students' Self-Efficacy

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Abstract

Learning analytics can be shown on dashboards (LADs) and provide formative feedback. Students use points of reference to compare their performance to. This study researches LADs using social reference frames and progress reference frames. LADs with social reference frames compare students' performance to their peers' performance. LADs with progress reference frames compare students' performance to their own previous performance. On the LADs, score delta is presented too. This shows students the difference between their score and their point of reference. Research has shown different effects of LADs with different reference frames. More specifically, the effect of LADs with different reference frames on self-efficacy has not yet received much attention. This study has researched the effects of LADs with a progress reference frame and a social reference frame on self-efficacy, the effect of the direction of score delta on self-efficacy, and whether score delta has a moderating effect. No significant results have been found. Previous research has found that LADs with reference frames increase motivation, social anxiety and stress. Possibly, these factors have mediated the effects. Nevertheless, a negative effect has not been found either. This means that the choice of the type reference frame is irrelevant.

Keywords: Learning analytics dashboards; social reference frame; progress reference frame; score delta; self-efficacy

The Effects of LADs with Reference Frames on Students' Self-Efficacy

Over the last years, society has become more and more data driven (Dencik et al, 2019). The technological advancements at the root of this change also create new possibilities for education (Volery & Lord, 2000). When learners use technology to learn, they leave digital footprints. These can be collected and analysed (Matcha et al., 2019). Based on this analysis, learners can be provided with formative feedback (Sedrakyan et al., 2020). This collection, analysis and reporting of data in the field of educational sciences is called learning analytics (Matcha et al., 2019).

The formative feedback can be presented on dashboards, called learning analytic dashboards (LADs) (Sedrakyan et al., 2020). LADs can be presented in different forms with different points of reference, the so called references frames (Wise, 2014). This paper will focus on LADs with a social reference frame and LADs with a progress reference frame. When using an LAD with the social reference frame, the scores of the learner and the average score of their peers are shown on the dashboard (Jivet et al., 2017). When using an LAD with a progress reference frame, the scores of the learner and the average of their previous scores are shown (Pfabigan et al., 2018).

Research on the effect of LADs with different reference frames show different outcomes for learners (Jivet et al., 2018). Some research has shown that LADs improve problem-solving skills (Yilmaz, 2021) and skill learning effectiveness (Wang & Han, 2020). However, the well-being of students using LADs might be negatively affected. Research has shown that students experience more stress when being compared to their peers through LADs (Tan et al. 2016; Wise et al., 2014).

Stress negatively influences self-efficacy (Schönfeld et al., 2017). Self-efficacy is the confidence people have in their capabilities to achieve accomplishments (Bandura, 2006). Self-efficacy influences learning performances and other factors concerning the wellbeing of

a person (Lee & Mao, 2016). Therefore, it is important to understand what the influence of LADs with reference frames is on self-efficacy. To the knowledge of the researcher, the only study researching the effects of dashboards on self-efficacy is done by Jonathan et al. (2017). They have found that the progress reference frame has a significant positive impact on self-efficacy. It is not unreasonable to assume that a difference in reference frames can influence the effect it has on self-efficacy, however this has not yet been researched. This study tries to close this gap in the literature. Therefore, this research is focussed on the effect of learning analytic dashboards on self-efficacy.

This study aims to broaden the knowledge on the effects of learning analytics dashboards on self-efficacy. The following question will be studied in this paper: What are the effects of learning analytics dashboards that present formative feedback with different types of references frames on students' self-efficacy?

Theoretical framework

Learning analytics (LA) is "the collection, analysis, and reporting of data about learners and contexts in which learning occurs" (Matcha et al., 2019, p. 1). The field of LA has been established in 2011 (Jivet et al., 2018). Since a few years the focus is on directly reporting data to support learners and teachers (Jivet et al., 2018). By doing so, LA can provide formative feedback to students and teachers (Wise et al., 2014). Formative feedback is information that helps the student to alter their thinking or behavior in order to improve their learning (Shute, 2008). This means that when LA is used to provide formative feedback, it can improve learning processes (Van Leeuwen, 2018).

The collected data can be about all sorts of factors that are part of learning, for example about how much students make use of interactive elements of online learning environments or how well they score on formative tests (Clow, 2013). When this kind of data

from previous students is collected, a model can be developed which can predict for current students what they need help with (Clow, 2013).

Among other ways, this formative feedback can be given by using dashboards. These learning analytics dashboards (LAD) visualize different indicators about the learning processes and learning contexts of learners (Matcha et al., 2019). The dashboards can be developed for different stakeholders, including learners. They can use the dashboards to reflect on their own learning process (Jivet et al., 2018).

The formative feedback shown on LADs can be provided by the use of points of reference. LADs then show the student their performance outcome and a point of reference (Wise et al., 2014), which helps the student to contextualize their performance outcome (Lim et al., 2019). Jivet et al. (2018) have described three sorts of reference frames: the progress, social and achievement reference frame. This study focusses on the progress reference frame and the social reference frame.

When using an LAD with the progress reference frame, two scores are visible. These are the score of the last formative test the student has taken and the average of all previous scores of the student. This means that this frame shows students their own historical data. This gives students the opportunity to visualize their progress (Jivet et al., 2017).

When using an LAD with the social reference frame, again two scores are visible. These are the score of the last formative test the student has taken and the combined average score of their peers on this same test. This means that the students can compare themselves to their peers (Pfabigan et al., 2018).

The influence of these reference frames can be explained by two theories, the temporal comparison theory and the social comparison theory. The progress reference frame can be explained by the temporal comparison theory. This theory describes that people compare their current achievements with their prior achievements (Wolff et al., 2018). The

social reference frame can be explained by the social comparison theory. This theory describes that people compare themselves to others (Buunk et al., 2013). People make these comparisons so that they can relate to a target, which is a goal they would like to achieve, to a standard, in order to measure themselves (Wolff et al., 2018).

In order to emphasize the difference between the two scores on the LADs, score delta can be made visible. This is done so that the learner can quickly compare their score to their point of reference. This third score shows the difference between the other two scores and can therefore be upward, downward or lateral (McHugh et al., 2021). This means that score delta has a different meaning per type of LAD. For example, when score delta is -5 for the progress reference frame, this means that the score of the student on the last formative test is five points lower than the average of all their previous scores. For instance, the student has scored 5 on their last formative test and the average of all their previous scores is 10. When score delta is -5 for the social reference frame, this means that the score of the student on the last formative test is five points lower than the combined average score of their peers. For instance, the student has scored 5 on their last formative test and the combined average of their peers is 10.

The effect of LADs with reference frames has been tested for different learning and motivation outcomes. Research on the performance of students shows positive outcomes. Fischer and Wagner (2018) found that both LADs with the progress reference frame as LADs with the social reference frame significantly improve students' grades. In the study of Ruiz et al. (2016), it became clear that showing LADs with the social reference frame to students improves their attention and effort whilst studying. Yilmaz (2021) researched effects of providing students feedback based on their learning analytics. The students received this feedback weekly and were able to review their learning process with this, so this study was using the progress reference frame. The problem-solving skills of the students improved

significantly. The research of Wang and Han (2020) was quite similar in their design. They found that the skill learning effectiveness of students had improved.

Research on motivation shows mixed outcomes. The results of Wise et al. (2014) shows that some students that score below the average of all students, are motivated by the LADs using a social reference frame. However, they also found that for other low achieving students these LADs with a social reference frame are seen as stressful and intimidating. Lim et al. (2019) too found that social anxiety rises when students compare themselves to their peers. In addition, Jivet et al. (2018) show in their systematic literature review that the effects of an LAD with a reference frame can be different for different students. For example, Kim et al. (2015) found that high achieving students already are motivated, so to use LADs with the social reference frame and compare them with peers might not have the same effect as comparing their scores to their own set goals, which they can do when using LADs with the progress reference frame. Low achieving students, on the other hand, did find the LADs presented in the study motivating which was correlated with learning achievement. Overall they found that the students that use the dashboards obtain higher scores. The LADs in their study present both the progress reference frame as the social reference frame.

Research has shown that the effects of the different types of reference frames on LADs differ. In addition, student preferences for the different reference frames on LADs differ. Konert et al. (2016) found that participants prefer LADs with the social reference frame, where Tabuenca et al. (2015) found that participants prefer LADs with the progress reference frame.

Not much research has yet been done on the effect of LADs with reference frames on self-efficacy. Self-efficacy is the belief people have in their capabilities to achieve accomplishments (Bandura, 2006). To the knowledge of the researcher, the only study conducted to research the relationship between self-efficacy and LADs, is that of Jonathan et

al. (2017). They have found that LADs with the progress reference frame have a significant

positive impact on self-efficacy (Jonathan et al., 2017). As previous research has shown both

positive and negative effects of LADs with reference frames on different aspects concerning

learning, it is logical to assume that LADs with different reference frames also might have

different effects on self-efficacy.

Self-efficacy influences learning performances and other factors concerning the

wellbeing of a person (Lee & Mao, 2016). When the self-efficacy of a person is high, it

increases intrinsic motivation and personal well-being. It reduces stress and lowers

vulnerability to depression (Bandura & Wessels, 1994). On the other hand, when the self-

efficacy of a person is low, this results in avoiding difficult tasks, low aspirations, more stress

and more vulnerability to depression. When a person with low self-efficacy fails, they are

slow in recovering their self-efficacy compared to a person who initially has high self-

efficacy (Bandura & Wessels, 1994). For this reason, it is important that more research

concerning the relationship between self-efficacy and LADs with reference frames is

conducted.

This study

This study researches further what influence the different reference frames presented

on LADs have on self-efficacy, what the effect of the direction of score delta is on self-

efficacy and whether this differs per reference frame. This leads to the following research

question: What are the effects of different types of references frames on learning analytics

dashboards that present formative feedback on students' self-efficacy and does score delta

have a moderating role? The following hypotheses were formed: (a) the type of reference

frame on an LAD has a significant influence on self-efficacy; (b) the direction of score delta

on an LAD has a significant influence on self-efficacy; (c) score delta has a moderating effect

on the relation between the type of reference frame and self-efficacy.

The first hypothesis has not been formulated into a certain direction. This is because very little research has been done to study the influence of LADs with reference frames on self-efficacy. Thereby, previous research has shown both positive and negative effects of LADs with both the reference frames on learning and wellbeing. This substantiates this choice.

With regard to the second hypothesis, it is reasonable to expect that score delta has both positive and negative impact on self-efficacy. When score delta is positive, a positive impact on self-efficacy can be expected and when score delta is negative, a negative impact on self-efficacy can be expected. Therefore, this hypothesis has not been formulated in a certain direction.

The third hypothesis is based on the fact that the participants see on their LAD both a type of reference frame and their score delta. It is logical to assume that score delta will have influence on how the self-efficacy of participants will be influenced when they interpret their LAD with either of the reference frames.

Method

Participants

This research has been conducted during the course Designing of Learning Situations – advanced at the University of Utrecht. All students enrolled in this course were asked to participate. At the start of the course, the participants filled out an informed consent, in which they agreed to the use of their data for this study. They could withdraw from the study at any given time.

A total of 167 students were enrolled in this course, of which 153 students have filled out the informed consent to participate in this study. However, not every student participated in each of the lessons during the eight weeks. Moreover, there was missing data on the self-

efficacy questionnaires of students that did participate. Eventually, there were 141 participants with valid datapoints.

The participants were aged between 18 and 54. Of these participants, 115 participants were aged between 18 and 24, 18 were aged between 25 and 34, 7 were aged between 35 and 44, 1 was aged between 45 and 54. Of the participants, 108 were female, 31 were male and 2 participants would rather not say. The participants followed this course as part of their studies, 50 participants were enrolled in the Educational Sciences pre-master program, 46 in the ALPO program, 38 in the bachelor of Educational Sciences and 7 participants in another program.

G*Power 3.1.9.7 was used to run the power analysis. A repeated measures ANOVA with within factors was used to analyse the results of this study. There were 2 groups and 4 measurements. The effect size was .25, α was .05 and power was .95. This means it was strived to achieve a sample size of at least 36 participants in this research.

Materials

Course

The course Designing of Learning Situations – advanced was a course of the bachelor study Educational Sciences at the University of Utrecht. During this course, students learned about designing learning materials, using the book "Ten Steps to Complex Learning. A Systematic Approach to Four-Component Instructional Design" (Van Merriënboer & Kirschner, 2017) and several papers. The course lasted eight weeks.

The course consists of four components: knowledge clips, tutorials, Q&A's, an instructional design assignment and a take home test. Each week, the students watched several knowledge clips on a particular topic in the course (e.g., designing learning tasks, or sequencing task classes). In these clips, questions about the material were presented during or after the clips using the program FeedbackFruits. The questions were multiple choice with

three answer options or a true/untrue statement. An example of a question was "Which parts

of the ADDIE-model are part of the 4C/ID model?". The possible answers were "analysis and

design", "analysis and evaluation" and "analysis and implementation". The first option was

the correct answer. The students were obligated to watch the clips and answer the questions

as part of the course requirements.

Each week, there was a Q&A in which students could ask questions about the course

material of that week. The Q&A's were not obligated.

The students also followed a tutorial each week. During the tutorials, the students

worked on a long instructional design assignment. Being present at the tutorials was part of

the course requirements.

At the end of the course, students received a take home exam. For this exam, students

wrote an essay based on a case. They had two weeks to write the essay.

This study very slightly altered the course, namely at the start of each tutorial,

students interpreted the dashboards and then filled out the self-efficacy questionnaire. This

took approximately ten minutes. Interpreting the dashboards and filling out the questionnaire

was the same for all students, whether they participated in this study or not. The dashboards

reflected the results of the students on the questions embedded in the knowledge clips. These

clips with questions were already part of the course, so this was not altered for this study.

For the current study, the course parts knowledge clips and the accompanying

questions and the learning analytics dashboards were of importance. The answers to the

accompanying questions served as input for the learning analytics dashboards to help students

monitor their mastery of the course literature.

Learning analytics dashboards.

The LADs were created in Power BI and shared through a link which was provided by

the tutorial teachers. On LADs using the social reference frame, the participants could see

their own score of that week, the average score of all students that week and the score delta which is the difference between the students' score and the group average. When score delta was positive, they had scored above average and when score delta was negative, they had scored below average. Score delta could also be zero, when the students' score and the group average were the same. These scores were shown in percentages. An example of the social reference frame on an LAD is visible in Figure 1.

Figure 1

Social reference frame dashboard
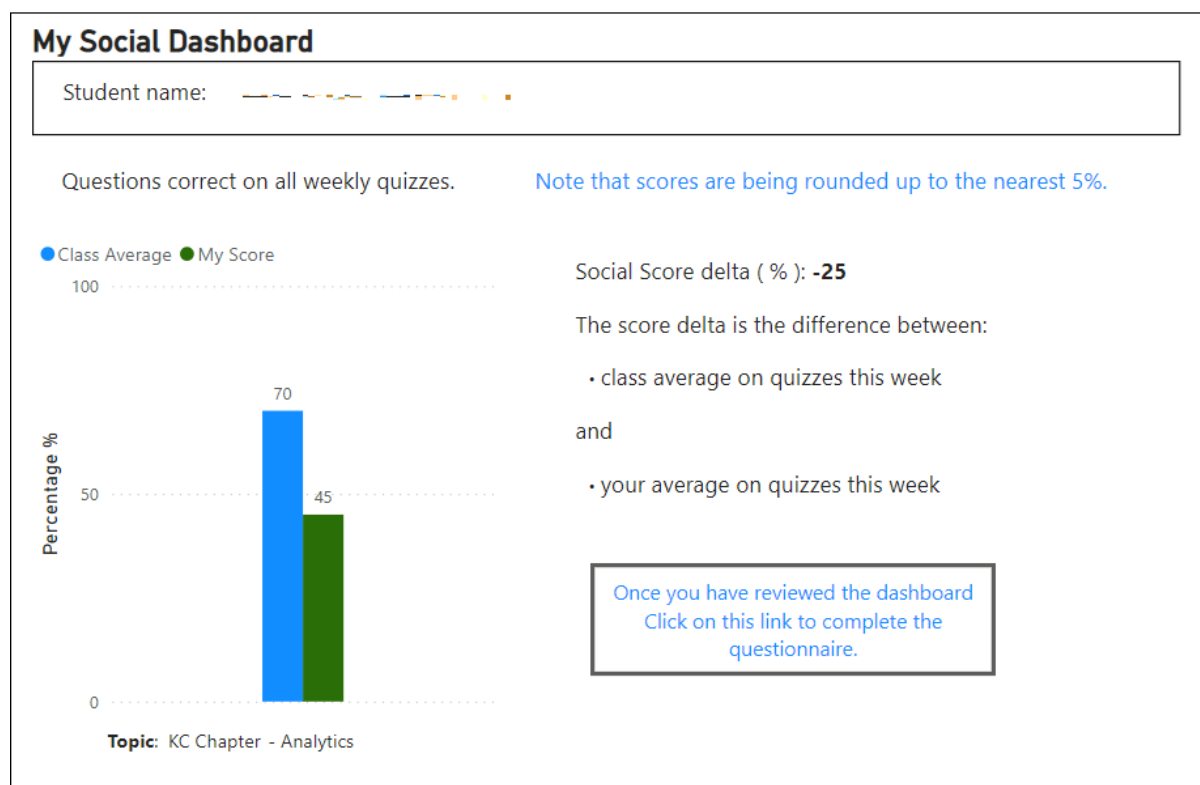
On LADs using the progress reference frame, the participants could see their own score of that week, their average scores per previous week and score delta which in this case is the difference between the student's score and the average of their previous scores. These scores were shown in percentages. An example of the progress reference frame on an LAD is visible in Figure 2.

Figure 2

Progress reference frame dashboard
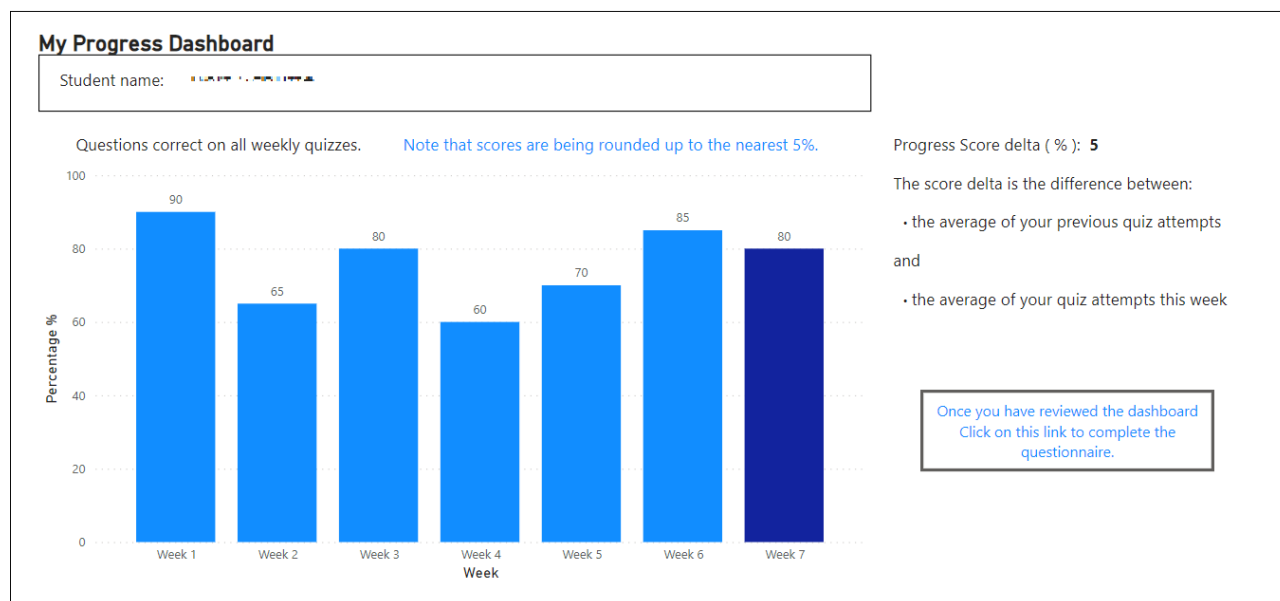
Self-efficacy questionnaire

The self-efficacy questionnaire intended to measure the self-efficacy of the participants after viewing a dashboard. The validated MLSQ-SE scale (Nielsen et al., 2017) was used for this purpose. This scale exists of two scales, the specific academic learning self-efficacy (SAL-SE) scale and specific academic exam self-efficacy (SAE-SE) scale. The scales were validated in a replication study by Nielsen (2020). The scales were both compared to the Rasch models requirements, which are strict standards for measurement quality, and were both found to be valid ($p < .05$) (Nielsen, 2020).

Both scales consist of four statements, which the participants answered using a five point Likert scale. An example of a statement of the SAL-SE scale is: "I'm certain I can understand the most difficult material presented in the readings for this course.". An example of a statement of the SAE-SE is: "I believe I will receive an excellent grade in this class.". The complete list of the statements on the scales can be found in Appendix A. The reliability of the SAL-SE scale in this study was $\alpha = .87$. The reliability of the SAE-SE scale in this

study was $\alpha = .92$. The reliability of a scale is seen as acceptable when Cronbach's alpha >

.80, which means that both scales used in this research are reliable (Field, 2018).

Design

      Initially this study was designed as a 2x3 factorial, switching replications design. The

same group of students was measured on the self-efficacy questionnaire in six possible

conditions. There were two within-subject factors: the factor *type of reference frame* and the

factor *direction score delta*. The factor type of reference frame has two levels, social

reference frame and progress reference frame. The factor direction score delta has three

levels, downward, lateral and upward. The factor direction score delta was based on the

actual performance of a student and was therefore not controlled within the study. As a result,

there was insufficient data on the level lateral. The power analysis showed that each group

should consist of at least 36 datapoints. However, groups consisting of the progress reference

frame with a lateral score delta existed of only 10 datapoints, for both the self-efficacy scales.

The groups consisting of the social reference frame with a lateral score delta existed of 32

datapoints for the SAL-SE score and 33 datapoints for the SAE-SE score. Therefore, the

study design was changed into a 2x2 factorial design in which there are only two levels of

direction score delta, namely downward and upward.

Procedure

      The course took eight weeks. Each week, the students filled out the questionnaire. In

this questionnaire, the eight statements of the two scales combined were presented. All

students were assigned to a tutorial group. In total, there were nine tutorial groups. The

students in tutorial groups with uneven numbers got the LADs with the progress reference

frame during the first five weeks, minus the first week. During the last two weeks, these

tutorial groups got the LADs with the social reference frame. The students in tutorial groups

with even numbers got the LADs with the social reference frame during the first five weeks

minus the first week, and the LADs with the progress reference frame during the last two weeks.

In the first week, the participants have not seen an LAD. They did watch the knowledge clips and filled out the questions, but as the LADs with the progress reference frame need historical datapoints, this LAD could not be shown yet. Therefore, none of the LADs have been shown in the first week.

During the first tutorial of the course, participants were asked to participate in this research and filled out an informed consent. The students that did not want to participate still watched the knowledge clips, answered the accompanying questions and used the dashboards and filled out the questionnaire, but their data were omitted from the sample.

At the beginning of each tutorial, the LADs were shown to the participants and immediately after this, the participants filled out a questionnaire about their self-efficacy. Then the answers to the accompanying questions and results of the LADs for the tutorial group were discussed in class. On all LADs a text was visible encouraging students to go back to the lecture and look through their answers on the questions after they viewed the dashboard.

The LADs were made available fifteen minutes before each tutorial and closed of fifteen minutes after each tutorial. As the tutorial groups were spread through the week, the exact times that the LADs were available, were different per tutorial group.

Analysis

The datapoints used, were collected in week two to week seven. This is because the participants did not view an LAD in their first week.

First, it was determined whether the data contained outliers. Second, the assumption of normality was tested by using Shapiro-Wilk's test. It was not necessary to measure the

assumption of sphericity, as both factors type of dashboard and direction of score delta contained only two levels.

Then, repeated measures within subjects ANOVA's were run to analyse the effect of the type of dashboard, direction of score delta and the interaction between these two variables on both the self-efficacy scores. The effect sizes were measured by using partial η^2.

Results

The descriptives of the SAL-SE score are shown in Table 1. The descriptives of the SAE-SE score are shown in Table 2.

Table 1. *Descriptives of SAL-SE*

	Number of datapoints	*M*	*SD*	Min	Max
Social upward	135	3.54	0.62	1.5	5
Social downward	90	3.35	0.67	1.25	5
Progress upward	115	3.42	0.65	1	4.75
Progress downward	186	3.39	0.58	1.75	4.5

Note. Social stands for social reference frame, progress stands for progress reference frame. Upward and downward refers to the direction of score delta. The minimal score a participant could achieve on the self-efficacy tests was 1, the maximum score was 5.

Table 2. *Descriptives of SAE-SE*

	Number of datapoints	*M*	*SD*	Min	Max
Social upward	134	3.42	0.68	1	5
Social downward	90	3.25	0.74	1	4.75

Progress upward	113	3.28	0.65	1	4.25
Progress downward	194	3.30	0.61	1.75	5

Note. Social stands for social reference frame, progress stands for progress reference frame. Upward and downward refers to the direction of score delta. The minimal score a participant could achieve on the self-efficacy tests was 1, the maximum score was 5.

A repeated measures within subjects ANOVA was used to investigate the effects of the type of reference frame and the direction of score delta on LADs on self-efficacy. First, the data was checked for outliers. No extreme outliers were found. Then, Shapiro-Wilk's test was used to assess the assumption of normality. This assumption was violated ($W = 0.96$, $p = < 0.001$).

When the assumption of normality is violated, the chance for a type I error is increased (Glass et al., 1972; Lix et al, 1996). This means that there is a larger chance that a false positive result will be found (Field, 2018). This risk was accepted by the researcher, and meant that when a significant result would be found, this result should be interpreted carefully.

No significant effect has been found for the type of reference frame on LADs on the SAL-SE score, $F (1, 518) = 2.34$; $p = .127$, partial $\eta^2 < .01$. No statistically significant main effect was found for the direction of score delta on LADs on the SAL-SE score, $F (1, 518) = 0.11$; $p = .743$, partial $\eta^2 < .01$. There was no significant effect found for the interaction between the type of reference frame and the direction of score delta on LADs on the SAL-SE score, $F (1, 518) = 0.01$; $p = .923$, partial $\eta^2 < .01$. The boxplots of the SAL-SE score have been made visible in Figure 3.

Figure 3

Boxplots SAL-SE score
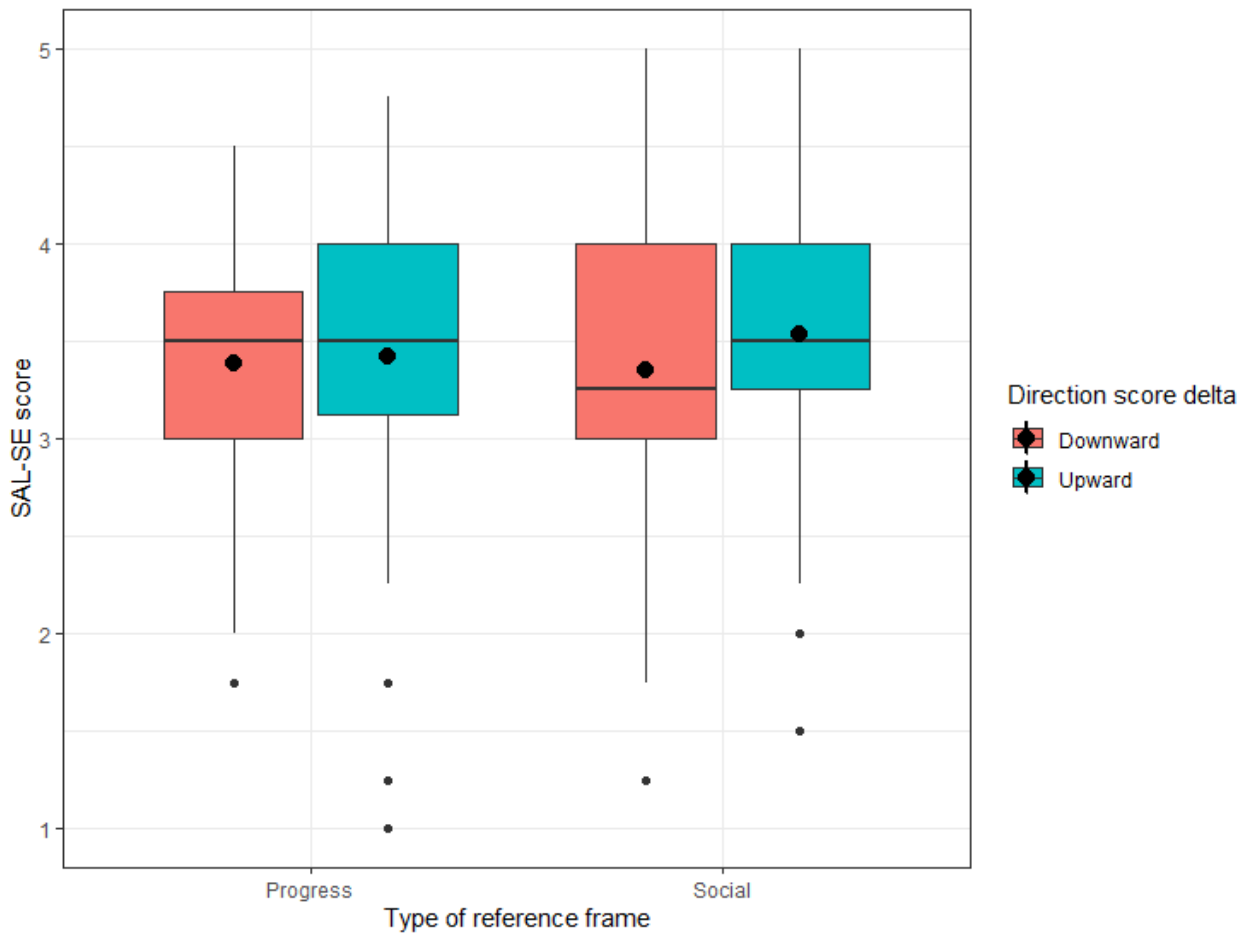
No significant effect of the type of reference frame on LADs on the SAE-SE score has been found, $F(1, 523) = 0.63$; $p = .426$, partial $\eta^2 < .01$. No significant effect of the direction of score delta on LADs on the SAE-SE score has been found, $F(1, 523) = 0.15$; $p = .697$, partial $\eta^2 < .01$. No significant effect of the interaction between the type of reference frame and the direction of score delta on LADs on the SAE-SE score has been found, $F(1, 523) = 0.07$; $p = .798$, partial $\eta^2 < .01$. The boxplots of the SAE-SE score have been made visible in Figure 4.

Figure 4

Boxplots SAE-SE score
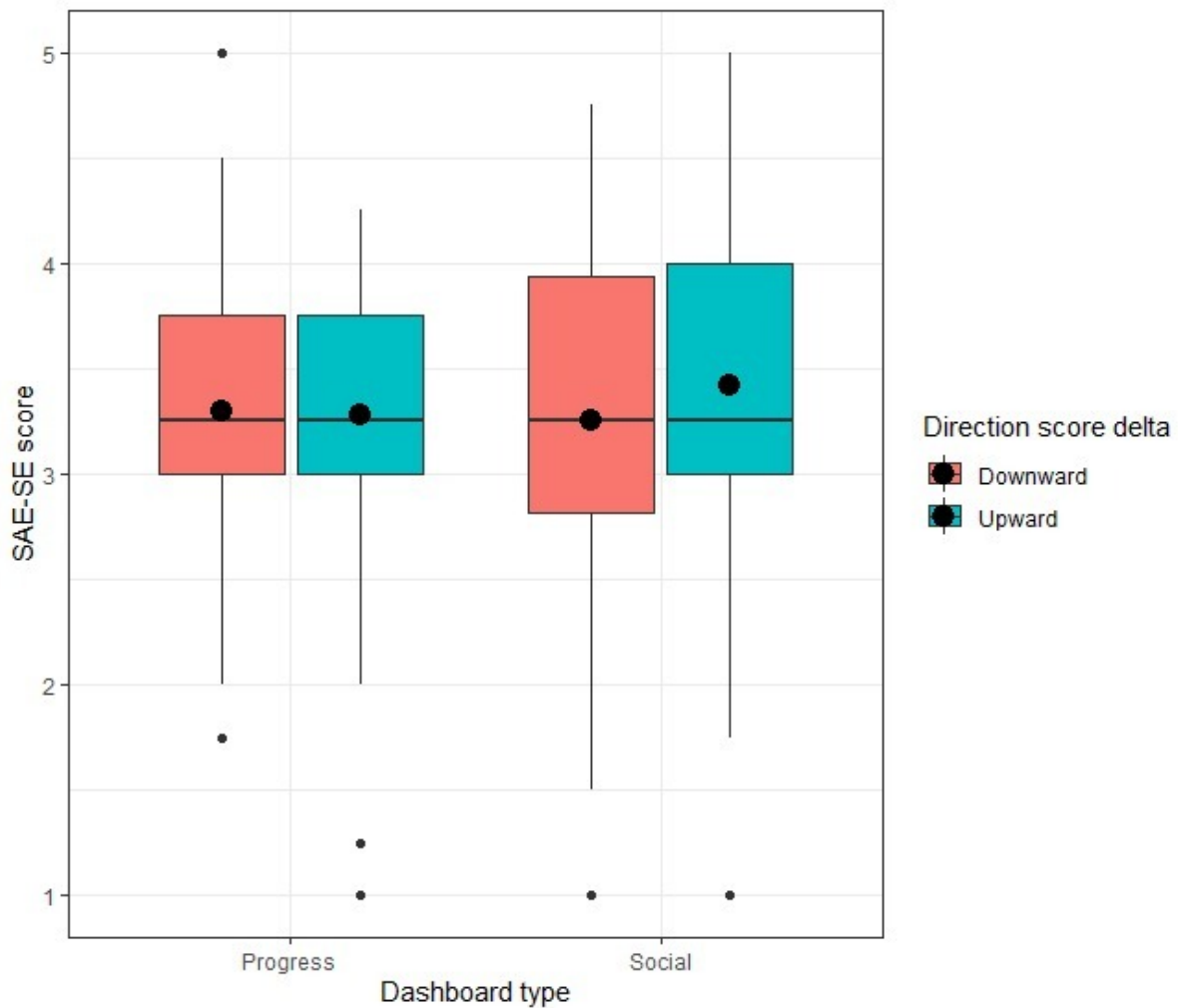
Discussion

The research question of this study is: What are the effects of different types of references frames on learning analytics dashboards that present formative feedback on students' self-efficacy and does score delta have a moderating role? To answer this question, three hypothesis were formed. First, these will be answered, then the main research question will be answered.

The first hypothesis is: the type of reference frame on an LAD has a significant influence on self-efficacy. The analyses show that for both the SAL-SE score as for the SAE-

SE score, there is no significant influence of type of reference frame on an LAD. This means that the type of reference frame on an LAD has no influence on the specific academic learning self-efficacy or on the specific academic exam self-efficacy.

The second hypothesis is: the direction of score delta on an LAD has a significant influence on self-efficacy. The analyses show that for both the SAL-SE score as for the SAE-SE score, there is no significant influence of the direction of score delta on an LAD. This means that the direction of score delta has no influence on the specific academic learning self-efficacy or on the specific academic exam self-efficacy.

The third hypothesis is: score delta has a moderating effect on the relation between the type of reference frame and self-efficacy. The analyses show that for both the SAL-SE score as for the SAE-SE score, there is no significant moderating effect of score delta on the relation between type of reference frame and self-efficacy. This means that this interaction has no influence on the specific academic learning self-efficacy or on the specific academic exam self-efficacy.

This research has shown that there is no effect of type of reference frame on an LAD or direction of score delta on an LAD on both types of self-efficacy. Neither has a moderating role for direction of score delta been found. This implies that regardless of score delta, the choice of reference frame on an LAD is not relevant for the effect of the LAD on self-efficacy. A possible explanation for this result could be that in previous research mixed results have been found for both LADs with progress reference frames as for LADs with social reference frames which could influence self-efficacy both positively and negatively. Wise et al. (2014) has found that students perceive LADs with the social reference frame as motivating, but also as stressful and intimidating. These results were different per student, as they perceive the LADs with the social reference frame in different ways. Kim et al. (2015) also found that the perception of the reference frames is different per student. They found that

higher performing students did not find the LADs with either type of reference frame motivating, as they were already performing well and did not have a higher point of reference that they could work towards. However, they found that lower performing students did find the LADs motivating. Lim et al. (2019) found that students' anxiety rose when they were compared to other students.

According to the social comparison theory and the temporal comparison theory, learners make comparisons in order to measure themselves with a goal they have set themselves (Wolff et al., 2018). As the influence of the types of reference frames is explained by this, it also explains these previous findings. If students were already performing well and did not have a clear goal to compare themselves with, the LADs with reference frames are not motivating. This also explains why no moderating effect of score delta has been found, as students without a clear goal to compare themselves to are also less likely to be affected by the direction of score delta.

In this research, the effects of LADs with the two types of reference frames on self-efficacy have been compared. These previous findings might explain why no effect has been found. Namely, these previous findings show different results per reference frame. Both positive and negative effects have been found for both LADs with progress reference frames and LADs with social reference frames. These effects are factors that influence self-efficacy. Possibly, these factors cancel each other out. When some students experience negative effects, like stress, and others positive effects, like motivation, they averagely experience neutral effects. If this is the case, it is reasonable that no significant result has been found. Even when score delta is amplifying the effect of the reference frames on LADs.

Limitations

The participants of this study all followed the same course and were mostly following the study programs that are part of the faculty of social sciences. Only 7 of the 141

participants followed a different program, it is unknown from what faculty. Therefore, most participants have the same profile which means that this study cannot be generalized to all students.

Next to that, there were no students without LADs. Because of that, it could not be compared what the influence is of using an LAD with a social reference frame, an LAD with a progress reference frame and using no LAD at all. However, this choice has been made because of previous research, which has shown that the use of LADs leads to higher learning performances (Fisher & Wagner, 2018). Therefore, it would be unethical to only let a part of the participants use the LADs.

Future research

Previous research has shown that LADs with reference frames can have different effects on different learners. This study has not found effects of LADs with different types of reference frames and score delta on self-efficacy. Possibly, these effects have not been found because of these different effects on learners. When some learners experience positive effects and others negative effects, they averagely experience neutral effects. Therefore, it would be interesting to further research learner preferences and find out whether there are certain pinpoints which can be used to predict which preferences learners will have.

Next to that, it would be interesting to gain more knowledge on score delta. This study is one of the first that introduces this score. It is relatively new and it has not before been tested in combination with the LADs. Through this study it became clear that self-efficacy is not influenced by the direction of score delta. However, it was not tested how students perceive this score, or what they take from it. This would be interesting for future research.

Theoretical and practical implications

This study adds information to the body of research that has been done concerning types of reference frames on LADs. Its findings are neutral, so it does not steer future

research into a certain direction. As to the knowledge of this researcher only one study concerning the influence of LADs on self-efficacy has been conducted before this study, the knowledge on this topic does need to be deepened. That is necessary to make substantiated statements about this topic.

The practical implications of this research are low, as the research on the use of LADs is still in an early phase. LADs need to be researched further before they could be implemented. However, this study does not promote nor prohibit the use of LADs with reference frames and score delta, as neither positive nor negative effects on self-efficacy have been found. This study does not advocate for a certain type of reference frame either.

Conclusion

This study has researched whether the type of reference frame on an LAD has influence on self-efficacy, whether the direction of score delta on an LAD has influence on self-efficacy and whether there is an interaction effect between these two factors. No significant results have been found, which suggests that the type of reference frame on an LAD does not alter self-efficacy. The direction of score delta does not alter self-efficacy either, nor is there an interaction effect between these two factors.

As previous research has shown that LADs with reference frames increase learning performance (Fisher & Wagner, 2018) and other factors concerning learning (Ruiz et al., 2016; Wang & Han, 2020; Yilmaz, 2021), LADs with reference frames might be an asset for education. However, this topic is relatively young and therefore first needs to be researched further. Previous research and advancements in technology show a promising future for the use of LADs with references frames in the aid of students education and self-efficacy. The results of this research imply that when an educational professional is using an LAD in a classroom setting to influence the students self-efficacy, the choice of reference frame for the LAD is irrelevant.

References

Bandura, A. (2006). Guide for constructing self-efficacy scales. *Self-efficacy beliefs of adolescents*, *5*(1), 307-337.

Bandura, A., & Wessels, S. (1994). *Self-efficacy* (Vol. 4, pp. 71-81). na.

Buunk, B. P., Gibbons, F. X., & Buunk, A. (2013). *Health, coping, and well-being: Perspectives from social comparison theory*. Psychology Press. https://doi.org/10.4324/9780203774106

Clow, D. (2013). An overview of learning analytics. *Teaching in Higher Education*, *18*(6), 683-695. https://doi.org/ 10.1080/13562517.2013.827653

Dencik, L., Redden, J., Hintz, A., & Warne, H. (2019). The'golden view': data-driven governance in the scoring society. *Internet Policy Review*, *8*(2), 1-24. http://doi.org/ 10.14763/2019.2.1413

Field, A. (2018). *Discovering statistics using IBM SPSS statistics*. sage.

Fischer, M., & Wagner, V. (2017). *Effects of timing and reference frame of feedback: Evidence from a field experiment in secondary schools*. Working Paper.

Glass, G. V., Peckham, P. D., & Sanders, J. R. (1972). Consequences of failure to meet assumptions underlying the fixed effects analyses of variance and covariance. *Review of educational research*, *42*(3), 237-288. https://doi.org/10.3102/00346543042003237

Jivet, I., Scheffel, M., Drachsler, H., & Specht, M. (2017, September). Awareness is not enough: Pitfalls of learning analytics dashboards in the educational practice. In *European conference on technology enhanced learning* (pp. 82-96). Springer, Cham. http://doi.org/10.1007/978-3-319-66610-5_7

Jivet, I., Scheffel, M., Specht, M., & Drachsler, H. (2018, March). License to evaluate:

Preparing learning analytics dashboards for educational practice. In *Proceedings of the 8th international conference on learning analytics and knowledge* (pp. 31-40). http://doi.org/10.1145/3170358.3170421

Jonathan, C., Tan, J. P.-L., Koh, E., Caleon, I., & Tay, S. H. (2017). Enhancing Students' Critical Reading Fluency, Engagement and Self-Efficacy Using Self-Referenced Learning Analytics Dashboard Visualizations. In W. Chen, J.-C. Yang, A. F. Mohd Ayub, S. L. Wong, & A. Mitrovic (Eds.), *Proceedings of the 25th International Conference on Computers in Education* (pp. 457-462). New Zealand: Asia-Pacific Society for Computers in Education.

Kim, J., Jo, I. H., & Park, Y. (2016). Effects of learning analytics dashboard: analyzing the relations among dashboard utilization, satisfaction, and learning achievement. *Asia Pacific Education Review*, *17*(1), 13-24. http://doi.org/ 10.1007/s12564-015-9403-8

Konert, J., Bohr, C., Bellhäuser, H., & Rensing, C. (2016, July). PeerLA-Assistant for individual learning goals and self-regulation competency improvement in online learning scenarios. In *2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT)* (pp. 52-56). IEEE. http://doi.org/10.1109/ICALT.2016.100

Lee, P. C., & Mao, Z. (2016). The relation among self-efficacy, learning approaches, and academic performance: an exploratory study. *Journal of Teaching in Travel & Tourism*, *16*(3), 178-194. http://doi.org/10.1080/15313220.2015.1136581

Lim, L., Dawson, S., Joksimovic, S., & Gašević, D. (2019, March). Exploring students' sensemaking of learning analytics dashboards: Does frame of reference make a difference?. In *Proceedings of the 9th international conference on learning analytics & knowledge* (pp. 250-259). https://doi.org/10.1145/3303772.3303804

Lix, L. M., Keselman, J. C., & Keselman, H. J. (1996). Consequences of assumption

violations revisited: A quantitative review of alternatives to the one-way analysis of

variance F test. *Review of educational research*, *66*(4), 579-619.

https://doi.org/10.3102/00346543066004579

Matcha, W., Ahmad Uzir, N., Gašević, D., & Pardo, A. (2019). A systematic review of

empirical studies on learning analytics dashboards: A self-regulated learning

perspective. *IEEE Transactions on Learning Technologies*, *13*(2), 226-245.

http://doi.org/10.1109/TLT.2019.2916802

McHugh, D., Feinn, R., McIlvenna, J., & Trevithick, M. (2021). A Random Controlled Trial

to Examine the Efficacy of Blank Slate: A Novel Spaced Retrieval Tool with Real-

Time Learning Analytics. *Education Sciences*, *11*(3), 90. https://doi.org/10.3390/

educsci11030090

Nielsen, T. (2020). The specific academic learning self-efficacy and the specific academic

exam self-efficacy scales: construct and criterion validity revisited using Rasch

models. *Cogent Education*, *7*(1), 1840009.

https://doi.org/10.1080/2331186X.2020.1840009

Nielsen, T., Makransky, G., Vang, M. L., & Dammeyer, J. (2017). How specific is specific

self-efficacy? A construct validity study using Rasch measurement models. *Studies in

Educational Evaluation*, *53*, 87-97. https://doi.org/10.1016/j.stueduc.2017.04.003

Pfabigan, D. M., Wucherer, A. M., & Lamm, C. (2018). Internal control beliefs and reference

frame concurrently impact early performance monitoring ERPs. *Cognitive, Affective,

& Behavioral Neuroscience*, *18*(4), 778-795. https://doi.org/10.3758/s13415-018-

0604-6

Ruiz, S., Charleer, S., Urretavizcaya, M., Klerkx, J., Fernández-Castro, I., & Duval, E. (2016,

April). Supporting learning by considering emotions: tracking and visualization a case study. In *Proceedings of the sixth international conference on learning analytics & knowledge* (pp. 254-263). https://doi.org/10.1145/2883851.2883888

Schönfeld, P., Preusser, F., & Margraf, J. (2017). Costs and benefits of self-efficacy: Differences of the stress response and clinical implications. *Neuroscience & Biobehavioral Reviews*, *75*, 40-52. https://doi.org/10.1016/j.neubiorev.2017.01.031

Sedrakyan, G., Malmberg, J., Verbert, K., Järvelä, S., & Kirschner, P. A. (2020). Linking learning behavior analytics and learning science concepts: Designing a learning analytics dashboard for feedback to support learning regulation. *Computers in Human Behavior*, *107*, 105512. https://doi.org/10.1016/j.chb.2018.05.004

Shute, V. J. (2008). Focus on formative feedback. *Review of educational research*, *78*(1), \ 153-189. https://doi.org/10.3102/0034654307313795

Tabuenca, B., Kalz, M., Drachsler, H., & Specht, M. (2015). Time will tell: The role of mobile learning analytics in self-regulated learning. *Computers & Education*, *89*, 53-74. https://doi.org/10.1016/j.compedu.2015.08.004

Tan, J. P. L., Yang, S., Koh, E., & Jonathan, C. (2016, April). Fostering 21st century literacies through a collaborative critical reading and learning analytics environment: user-perceived benefits and problematics. In *Proceedings of the sixth international conference on learning analytics & knowledge* (pp. 430-434). https://doi.org/10.1145/2883851.2883965

Van Leeuwen, A. (2019). Teachers' perceptions of the usability of learning analytics reports in a flipped university course: When and how does information become actionable knowledge?. *Educational Technology Research and Development*, *67*(5), 1043-1064. https://doi.org/10.1007/s11423-018-09639-y

Van Merriënboer, J. J. G., & Kirschner, P. A. (2017). *Ten Steps to Complex Learning. A*

Systematic Approach to Four-Component Instructional Design (3rd Edition).

Mahwah, NJ: Lawrence Erlbaum Associates.

Volery, T., & Lord, D. (2000). Critical success factors in online education. *International journal of educational management.* https://doi.org/10.1108/09513540010344731

Wang, D., & Han, H. (2021). Applying learning analytics dashboards based on process-oriented feedback to improve students' learning effectiveness. *Journal of Computer Assisted Learning*, *37*(2), 487-499. https://doi.org/10.1111/jcal.12502

Wise, A. F. (2014, March). Designing pedagogical interventions to support student use of learning analytics. In *Proceedings of the fourth international conference on learning analytics and knowledge* (pp. 203-211). https://doi.org/10.1145/2567574.2567588

Wise, A. F., Zhao, Y., & Hausknecht, S. N. (2014). Learning analytics for online discussions: Embedded and extracted approaches. *Journal of Learning Analytics*, *1*(2), 48-71. https://doi.org/10.18608/jla.2014.12.4

Wolff, F., Helm, F., & Möller, J. (2018). Testing the dimensional comparison theory: When do students prefer dimensional comparisons to social and temporal comparisons?. *Social Psychology of Education*, *21*(4), 875-895. http://doi.org/10.1007/s11218-018-9441-2

Yilmaz, F. G. K. (2021). Utilizing Learning Analytics to Support Students' Academic Self-efficacy and Problem-Solving Skills. *The Asia-Pacific Education Researcher,* 1-17. https://doi.org/10.1007/s40299-020-00548-4

Appendix A

SAL-SE

1. I'm certain I can understand the most difficult material presented in the readings for this course.

2. I'm confident I can understand the basic concepts taught in this course.

3. I'm confident I can understand the most complex material presented by the instructor in this course.

4. I'm certain I can master the skills being taught in this class.

SAE-SE

1. I believe I will receive an excellent grade in this class.

2. I'm confident I can do an excellent job on the assignments and tests in this course.

3. I expect to do well in this class.

4. Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.