

Development and Evaluation of an Assessment Tool for Self-Reflection

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Abstract—Self-reflection is an important competence for self-directing one's learning process in an effective way. However, not all students are sufficiently well equipped with this ability. To help students acquire this ability, we conceptualize our notion of self-reflection by extending existing models. On this basis, we develop an assessment tool for self-reflection. Based on about 300 data sets, we evaluate the quality of our assessment tool by analyzing to what extent it reliably measures the different aspects of self-reflection. By performing a Principal Component Analysis, we identify four factors that we relate to the theoretical conceptualization of our notion of self-reflection.

Index Terms—self-reflection, assessment tool, test evaluation

I. MOTIVATION

For effectively self-directing one's learning process, it is essential to identify the state of one's abilities, as well as one's individual needs for successfully tackling the next learning increment. Becoming aware of this current state and need of oneself requires some thorough contemplation, e.g. of one's emotions, one's actions or non-actions, and of the resulting consequences. The underlying skill of this kind of contemplation we denote as *self-reflection*.

Especially within technical domains, the skill profiles we, the lecturers, aspire to foster in our students mainly focus on technical skills, with a bit of garnish in the shape of social competences such as presentation or communication skills. Personal competences such as self-esteem, reliability, self-reliance or the above mentioned self-reflection we usually take for granted, and thus do not explicitly address them in our teaching.

However, experience shows that students entering university are not always sufficiently equipped with these skills. Instead of lamenting this observation as an indicator of a deplorable decline of society, it is more conducive to explicitly address the situation and to support students in catching up on those skills they lack.

To achieve this, we require a thorough understanding of the meaning of *self-reflection*, and of its manifestations in human actions and behavior. In addition, for effectively supporting students to improve their skills in this area we need an

appropriate assessment tool, in order to help students that are not yet sufficiently self-reflective to become aware of the level of their own expertise and/or development potential.

II. RELATED WORK

Self-reflection has been studied for several decades. More than 80 years ago, Dewey described reflection as a cognitive process with which a person addresses their notions and opinions and their possible consequences. As well, he states that a previous experience of the limitations in one's actions is helpful for creating a learner's willingness to enter into a self-reflection process [6].

Kolb and Fry refine the notion of a reflection process into the concept of a learning cycle that starts from a concrete experience which is analyzed by reflective observation, derives an abstract conceptualization and then actively experiments with this conceptualization [14]. The value of personal experience and the role of emotions within the reflection process are contributed by Bould et al. [4]. Gibbs revised and expanded the learning cycle of Kolb and Fry to a reflective cycle with six stages, incorporating the description of emotions as well as an explicit evaluation of the concrete experience [9].

Greif observed that although self-reflection is a valuable means for learning and personal development, many people tend to *avoid* self-reflection. He analyzed the reasons for and consequences of this avoidance [11].

As a basis for systematically assessing self-reflection skills, a variety of scales were defined and corresponding questionnaires designed. The private self-consciousness scale (PrSCS) focusses on the operationalization of self-related thinking [8], but in fact measures other aspects than self-reflection [5], including rumination [2]. The rumination-reflection questionnaire [16] diagnoses whether a test person ruminates rather than reflects, but does not assess the skill level. The self-reflection and insight scale (SRIS) [10] addresses whether the test person is engaged in self-reflection at all, is aware of a need for self-reflection, and assesses the degree of insight the test person has into their underlying thoughts and motives.

III. GOALS

When relating existing assessment tools for self-reflection with conceptual models of the process of self-reflection, it

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quickly becomes obvious that the scales of the assessment tools are only partially (if at all) aligned with the different stages that the different process models define. As a consequence, the existing assessment tools are not well suited for identifying which stages of the reflection process already work sufficiently well for a specific test person, and where the test person still requires some support and improvement.

To remedy the situation, we introduce an assessment tool that aims at explicitly addressing the different stages of our conceptualization of self-reflection skills. As a next step, we evaluate our assessment tools with respect to the quality criteria of *validity* and *reliability*, i.e., the correspondence to the underlying model and the accuracy of the measurement.

Thus, we address the following research questions with respect to our assessment tool:

- 1) To what extent does our assessment tool measure the various self-reflection aspects in a reliable way?
- 2) To what extent can we identify in our test data sets the various self-reflection aspects that we specified in our theoretical model?

IV. DEFINING OUR NOTION OF SELF-REFLECTION AND INVOLVED SKILLS AND ATTITUDES

As a basis for fostering self-reflection skills in our students, we first need to clarify our own understanding of what self-reflection involves. Therefore, in a first step we define our own notion of self-reflection, as an extension of the existing models to which we referred to above. Furthermore, we organize these self-reflection activities into a systematic process (see Fig. 1), which starts from a concrete experience, proceeds via situative self-observation and self-awareness, then applies situative analysis, and finally identifies some underlying principles and patterns by abstracting from several previous concrete experiences. As well, in our model we include the underlying attitude and some involved skills that constitute a desirable foundation for self-reflection efforts.

A. Aspects of Self-Reflection

When embedded into the context of reflective professional learning, self-reflection is a complex skill that consists of a variety of different aspects.

Concrete Experience

Similar to [4] and [14], we understand self-reflection as a processing phase that follows up on some previous concrete experience. Thus, as an initial basis for self-reflection, we require some concrete experience as a starting point.

Self-Observation and Self-Awareness

Based on the initial concrete experience, the first actual step of self-reflection consists of observing oneself in the concrete experience situation as it is, holistically and in an attentive, nonbiased and open minded way, in order to gain self-awareness as a result. Among others, this self-observation comprises bodily aspects (such as physical well-being) as well as mental aspects (e.g., one's mood). Self-observation is also comprised in other self-reflection models (e.g. [9] and [3]).

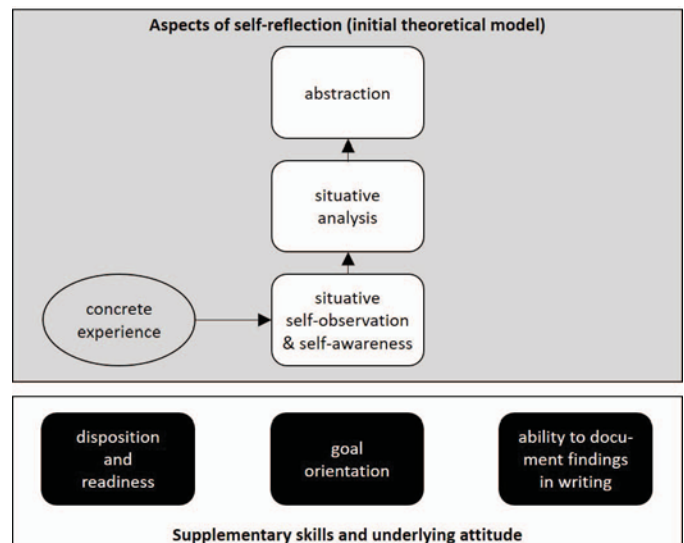


Fig. 1. Theoretical Model of different aspects of a systematic self-reflection process, with supplementary skills and underlying attitude

Since the result of the self-observation process, i. e., the self-awareness, forms the basis of the further stages of self-reflection, it is recommendable to document the findings of this stage in writing, as is suggested e. g. by [3]. However, the *ability to document findings in writing* is a skill that is useful for, but not integral part of, self-reflection. Rather, we consider this skill to be a useful tool that is helpful in a variety of other contexts as well, such as scientific writing. Therefore, we classify this aspect as being a supplementary skill for self-reflection (see section IV-B).

Situative Analysis

Analogously to the reflection process model of Atkins and Murphy [3] and [9], we see the critical situative analysis of the findings from self-observation as an important part of the self-reflection process. By analysis, we denote the process of discerning different parts, elements or aspects of some *whole* under consideration, as well as their interrelations and dependencies.

For example, by critical situative analysis, we derive cause-and-effect relationships in both our actions and emotions. Furthermore, situative analysis helps us to identify possible alternative actions that we could have taken, and to develop hypotheses on the suitability of these alternatives and on their effect on the surrounding context of our actions.

Note that [14] do not distinguish our notions of *self-observation and self-awareness* and *situative analysis*, but rather combine them into the single item *reflective observation*.

Abstraction and General Findings

From the parts and interrelations we discerned by situative analysis, we intend to identify the underlying patterns, mechanisms and causalities, as some kind of general findings that we draw from a variety of concrete experiences. These are essential for moving from merely copy-pasting a behavioural

pattern that we previously experienced as being successful, towards a deeper understanding of the *underlying principles* behind this success. (Note that the same holds true for the analysis and abstraction of negative experience, i.e., failures.) Having identified these principles is an important step towards transferring one's competences into other contexts, thus empowering oneself to successfully deal with challenges that are entirely new. The model of Kolb is one of the few that includes this stage of the self-reflection process as *abstract conceptualisation* [14].

Many existing conceptualizations of self-reflection focus mainly on the reflection and analysis of concrete experience. However, identifying the underlying principles requires abstracting from a set of concrete experiences. Thus, we incorporate a stage of abstracting into our conceptualization of self-reflection. This abstraction can be directed toward a variety of facets we reflect upon, such as psychological ones (moving from concrete emotions or motivations in specific situations towards a general disposition or one's general motives), actions (from single instances to general behavioural patterns, how-tos or even algorithms) or social interaction (e.g. from a single dialogue to the patterns of reciprocal interaction loops [1]).

Not Included Aspects from other Models

In our model, we decided to explicitly omit some aspects that are included in some other models. One of these aspects is the *evaluation* of situations. From our experience, labelling something as "good" or "bad" quite often is a futile exercise. This is mostly due to the fact that the label resulting from an evaluation process is highly dependant of the underlying value system, and of the specific context in which something occurs.

Assume, for example, that if you yell, you tend to intimidate other people. If you apply this *underlying principle* in the role of elementary school teacher in front of a class of children as some sort of 'welcoming ritual', the effect is probably "bad". If, however, you apply the same principle when you are physically attacked while walking home from work through an otherwise deserted park at night, the effect is probably "good". Therefore, we prefer to focus on the aspect of "cause and effect" (i.e., the result of abstraction), leaving it up to each individual to select from their portfolio what they deem to be appropriate in a certain situation.

Another aspect that we explicitly excluded is the *planning* of future actions, which occurs e.g. as *active experimentation* in [14] and as *action plan* in [9]. Both instances basically focus on copy-pasting behavioural patterns to similar situations. Here again, we prefer the idea of understanding the *underlying principle*, which allows to act appropriately in new contexts or in variations of previous behavioural patterns.

B. Supplementary Skills and Attitude

In addition to the different core aspects of self-reflection mentioned above, we deem some supplementary skills and attitudes to be helpful for supporting the self-reflection process.

Disposition and Readiness

Inherent to self-reflection is the chance – or risk – to become

aware not only of one's strengths, but also of one's own improvement potential. Literature observes that many people shy away from self-reflection, in order to maintain their level of self-respect and self-esteem [11, p. 23], [12], [7, pp. 215 ff.], especially in situations that were more of a flop than a success in the first place. However, especially in situations that offer major improvement potential, self-reflection could be one means of learning effectively.

Therefore, the willingness to grasp the nettle and look at one's improvement potential is essential for setting up self-reflection.

Goal Orientation

In everyday language, *self-reflection* corresponds to thinking about oneself. However, not every kind of thinking about oneself is fruitful in our sense of self-reflection. For example, continuously ruminating over things of the past without reaching any kind of conclusion or consequent action is not helpful for getting on. Rather, it is helpful to engage in goal and outcome oriented reflection practices.

Ability to Document Findings in Writing

Generally, expressing our thoughts in writing helps us to become more precise and specific in our train of thoughts and in the conclusions we draw. Moreover, conclusions that we capture in writing are not as transient as mere spiritual thoughts. Having some kind of persistent documentation of our train of thoughts and of our conclusions facilitates to build on these conclusions and to stick to our intentions and resolutions in the future. Thus, the *ability to document findings in writing* is a highly useful supplementary skill for self-reflecting.

Summing up, we focus our model of self-reflection on the *situative self-observation and self-awareness* of a concrete experience, followed by first a *situative analysis* and then an *abstraction*, in order to identify the underlying principles. As supplementary skills and attitudes that are conducive for self-reflection, we include the *disposition and readiness* to engage in self-reflection at all, the *goal orientation* that helps to effectively direct the self-reflection efforts, and the *ability to document findings in writing*, in order to make our findings and insights both more precise and persistent.

V. DEVELOPING THE ASSESSMENT TOOL

As a next step, we develop an assessment tool for self-reflection skills, based on our theoretical model. It comprises a total of 47 statements. 27 of these aim at addressing the core skills of self-reflection, while the remaining 20 items focus on the supplementary attitudes and skills. For each of these items, participants self-assess the extent to which they fulfill the statement, with the options "entirely", "to a large extent", "half and half", "a little" and "not at all".

Note that the original assessment tool is in German. Thus, both the questions and the answer options provided here were translated from the original assessment tool.

To measure the different aspects of self-reflection as defined in Section IV in a reliable way, every aspect should be addressed by several items. Therefore, we associated each item

of our assessment tool with one aspect of our model, with which we initially expected it to correspond. Table I specifies the number of questions per aspect, as initially intended.

The items for addressing the core aspects of self-reflection are documented in Table IV in Section VI-B.

Finally, Table II lists the items for assessing the supplementary attitudes and skills as defined in Section IV. Note that in the last items of *disposition and readiness* and *goal orientation*, respectively, the answers' scale needs to be inverted in order to correspond with the other items.

TABLE I
NUMBER OF QUESTIONS ON EACH ASPECT OF SELF-REFLECTION IN THE INITIAL THEORETICAL MODEL

Core Aspects of Self-Reflection	# items
situative self-observation and self-awareness	6
situative analysis	11
abstraction	10
Supplementary Attitudes and Skills	# items
disposition / readiness	9
goal orientation	8
ability to document findings in writing	3

TABLE II
STATEMENTS FOR ASSESSING SUPPLEMENTARY ATTITUDES AND SKILLS

Disposition / Readiness
When I am confronted with things that are foreign to me, I am able to get into them.
Being able to assess what I'm thinking about is important to me.
Understanding my feelings and their meaning is important to me.
It is important to me to understand where my thoughts come from.
I understand the benefits of thinking about my actions.
Reflecting on me I deem to be important.
I am interested in analyzing my own behaviour.
Generally, I am willing to reflect deliberately on my behaviour.
In my point of view, thinking about things of the past is a waste of time. [inverse scale]
Goal Orientation
I think about how important my goals are for me, and about their value to me.
I have professional goals.
I am aware of what I am willing to invest into reaching my goals.
When I am resolved to do something, I generate a concrete plan that specifies the steps for achieving what I want to achieve.
When I am resolved to do something, I put it into action.
After reflecting on what I can do better the next time in a similar situation, I try out my findings at the next possible opportunity.
After uncomfortable or embarrassing situations, I find it hard to get into new things. [inverse scale]
Ability to Document Findings in Writing
I find it easy to document in writing my thoughts on my own behaviour.
I find it easy to not only identify explanations for my actions, but to put them into writing as well.
I am well able to document negative experiences in writing.

VI. EVALUATING THE QUALITY OF THE ASSESSMENT TOOL

After conceptualizing our notion of self-reflection and designing an assessment tool, we now have to validate this tool as a next step. To evaluate our assessment tool, we need a sufficiently large set of test data, which we can analyze with respect of the quality criteria of *validity* and *reliability*.

First, we piloted initial versions of the assessment tool with two sets of about 20 students each, in order to optimize understandability and unambiguousness of our item descriptions.

The resulting syntactically refined version was then integrated into our first-semester action day [17] that took place in October 2019 at the beginning of the winter term. This action day is part of the onboarding activities that we organize for our freshmen students, to facilitate their start at our university. During this action day, students tackle several team challenges which foster social interaction and networking among students. As well, all students run through a variety of diagnostic assessments for competences that we deem to be relevant for studying computer science related topics (see [13] for technical and methodical skills, [15] for base competencies).

By incorporating our self-reflection assessment tool into our first-semester action day, we were able to gather a set of almost 300 sample data from our target group, i.e., first year students of computer science related study programs at our institution. Based on these data, we can now analyze from a statistical point of view the quality of our self-reflection assessment tool.

A. Reliability Analysis

As a first evaluation approach, we conducted a reliability analysis to evaluate the quality of our test. Generally speaking, reliability describes the degree of accuracy of a measurement, where the degree of internal consistency of the scales is reported by the reliability coefficient Cronbach's Alpha (α). On the basis of this coefficient, we can clarify to which extent the items build a reliable scale and therefore measure the underlying construct, i.e., in our case the different aspects of self-reflection and its supplementary skills and attitudes.

For the supplementary skills and attitudes, Table III lists for each scale the number of valid data sets that could be used on this scale, the scale length (i.e., the number of items in our assessment tool that address this scale), the value of Cronbach's Alpha, the minimum and maximum values, the means and the standard deviation.

With values for Cronbach's Alpha ranging from 0.77 to 0.86, the internal consistency of the scales on the supplementary skills and attitudes is good. As well, the mean values are of an intermediate level, while standard deviations are well-diversified. Therefore, all values combined indicate that our assessment tools provides a broad coverage and measurement of the three different components in our supplementary skills and attitudes. Thus, for these three components, we can attribute a good quality to our assessment tool.

However, results for the core aspects of our theoretical model of self-reflection were less concise. Therefore, we use

TABLE III
DESCRIPTIVE STATISTICS FOR THE RELIABILITY ANALYSIS OF THE SUPPLEMENTARY SKILLS AND ATTITUDES: SIZE OF DATA SET, SCALE LENGTH, CRONBACH'S ALPHA, MINIMUM AND MAXIMUM VALUE, MEAN VALUE AND STANDARD DEVIATION

Supplementary Skill or Attitude	N	Scale Length	Cronbach's Alpha	Min	Max	M	SD
disposition and readiness	298	6	0.78	1.78	5.00	3.83	0.62
goal orientation	297	8	0.77	1.75	5.00	3.72	0.61
ability to document findings in writing	296	3	0.86	1.00	5.00	2.70	1.05

a different approach to analyse and evaluate the corresponding items of our assessment tool.

B. Factor Analysis

Literature, theoretical considerations and practical observation indicates that self-reflection is not a uni-dimensional construct, but rather comprises several different aspects. As the core aspects of our initial theoretical model of self-reflection are only weakly supported by Cronbach's Alpha, we use an exploratory factor analysis in order to extract descriptive and explanatory factors from our data. Generally, factor analysis is a statistical method for identifying groups of related items, where each of the groups represents some underlying factors, and where the factors of one group are independent from the factors of the other groups.

To achieve this, factor analysis uses statistical correlations to identify factor structures. In a next step, these factor structures are then interpreted in terms of content. Factor loadings are a measure of the correlation of variables with the factor, and indicate the degree of commonality between variable and factor. The height of the factor loading indicates whether a variable has little or much in common with a factor; i.e., the higher the loading, the greater is the significance of that variable for that factor.

As stated before, we conceptualized from a theoretical point of view different components of self-reflection. In the following, we analyse whether we can identify these components in our data, by performing a Principal Component Analysis (PCA) to extract the most important independent factors from our data. This leads to a Kaiser-Meyer-Olkin measure of sampling adequacy of 0.747, representing a relatively good factor analysis. Furthermore, Bartlett's test of Sphericity is significant ($p < 0.001$), indicating that correlations between items are sufficiently large for performing a PCA. Note that only factors with eigenvalues ≥ 1 were considered.

Examination of Kaiser's criteria yields empirical justification for retaining four factors with eigenvalues exceeding 1, which account for 38.17 of the total variance. Among the different factor solutions, the varimax-rotated four-factor solution yields the most interpretable solution. Most items load highly on only one of these four factors.

Table IV lists those 27 items of our assessment tool that are meant to address core aspects of self-reflection, clustering them with respect to the factor on which each item loads most highly. Factorloadings are indicated in the corresponding column. The column labeled *Intended* denotes the self-reflection

aspect that we aimed at with each item, respectively, in our original theoretical model of self-reflection:

- SOA – situative self-observation and self-awareness
- ANA – situative analysis
- ABS – abstraction

For the first three factors, horizontal lines emphasize that some items that load on this factor were initially intended towards other core aspects of self-reflection than the other items loading on this factor (see column labeled *Intended*). Note that for the fourth factor, all of the items loading on this factor were aimed at the same core aspect in our initial model.

As a next step, we analyse the item clusterings that load on the different factors, and interpret their commonalities within a factor as well as the differences between factors.

The first six items that load most highly on factor I are exactly those items that were intended to address the *situative self-observation and self-awareness*. In addition, item *I am aware of my improvement potential* loads on factor I as well, although we initially intended this item to address the core aspect of *abstraction*. One plausible explanation would be that students interpreted this item as relative to a situative concrete experience, where they did not act in the best possible way within a specific situation, rather than relating this item to a more abstract awareness of their general, overall improvement potential. Thus, we denote factor I as *situative self-observation and self-awareness*.

Of the eleven items that were initially intended to address the *situative analysis*, five load most highly on factor II, while the other six items load most highly on factor III. As well, two of the items that were intended to address *abstraction* load most highly on factor II, while two other ones of those items load most highly on factor III.

When analyzing the items loading on factor II for commonalities, it quickly becomes obvious that all of them address self-centered, action-oriented issues – five of them by analysing a specific situation, two of them by abstracting towards more general findings and underlying principles. Therefore, we denote factor II as *self-centered, action-oriented situative analysis and abstraction*.

In contrast to this, all items that load most highly on factor III deal with analysing or abstracting experience that focusses on interaction, social context or the way our environment influences the experiences we make. Thus, we denote factor III as *social context oriented situative analysis and abstraction*.

Finally, factor IV comprises the remaining items that were initially intended to address *abstraction*. Looking into these

TABLE IV
RESULTS OF THE FACTOR ANALYSIS OF THE ITEMS ON CORE ASPECTS OF SELF-REFLECTION ($N = 299$)

Factor I:	Factorloadings	Intended
I realize when my concentration decreases while I am working.	.62	SOA
I am aware of the physical condition of my body.	.72	SOA
I am able to observe myself from the outside.	.34	SOA
I realize when my mood changes.	.58	SOA
I notice consciously when I'm happy or content.	.31	SOA
I notice consciously when I'm downcast or feeble.	.32	SOA
I am aware of my improvement potentials.	.38	ABS
Factor II:	Factorloadings	Intended
In the face of an upcoming task, I think about the concrete steps I have to take for successfully dealing with this task.	.39	ANA
While I solve a task or a problem, I am consciously aware of my thinking processes and my train of thoughts.	.57	ANA
After successfully solving a task or a problem, I deliberately think about how exactly I proceeded when dealing with the task.	.68	ANA
After succeeding in something I aspired to, I deliberately think about what I did myself to bring about this success.	.73	ANA
After fouling something up, I ruminate about the probable causes.	.64	ANA
After succeeding in something I aspired to, I deliberately think about what I can do myself to repeat a similar success in the future.	.61	ABS
After fouling something up, I ruminate about what I can improve in similar situations in the future.	.64	ABS
Factor III:	Factorloadings	Intended
It is easy for me to register positive / negative vibes in my surroundings.	.40	ANA
When I discern my environment, I realize the way in which it influences me and my actions.	.49	ANA
I consciously think about my experiences.	.58	ANA
In certain situations I think about how others see me and about the effect I have on others.	.51	ANA
In many cases, I can explain why I act in a certain way.	.46	ANA
Quite often, I think about why I am the way I am.	.67	ANA
I am aware of the "buttons", which, when pressed, trigger some behavioural patterns that are typical for me.	.43	ABS
Based on several concrete experiences, I draw conclusions on the general impression I make on others.	.53	ABS
Factor IV:	Factorloadings	Intended
I am aware of my feelings.	.46	ABS
I am aware of the motives of my actions.	.52	ABS
I am aware of my fundamental motives.	.69	ABS
I know what generally motivates me in life.	.69	ABS
I am aware of my strengths.	.46	ABS

items in detail, it becomes apparent that all of them focus on one's general disposition, i.e., one's fundamental motives, feelings and strengths. To express this commonality, we denote factor IV as *general self-awareness of disposition*.

C. Reliability Analysis of Identified Factors

To evaluate the quality of our assessment tool for the four factors we identified by factor analysis, we perform a reliability analysis in an analogous way as described in Section VI-A.

For our scales, i.e., the identified factors of self-reflection, Table V lists for each scale the number of valid data sets that could be used on this scale, the scale length, the value of Cronbach's Alpha, the minimum and maximum values, the means and the standard deviation.

With values for Cronbach's Alpha ranging from 0.59 to 0.77, the internal consistency of the scales on the core aspects of self-reflection is acceptable to good, albeit slightly lower than the consistency of the scales on the supplementary skills and attitude. Note that minimum values are somewhat higher

than for the supplementary skills. As well, the mean values are of an intermediate level, while standard deviations are still well-diversified, but slightly lower than for the supplementary skills. Therefore, all values combined indicate that our assessment tool provides a broad coverage and measurement of the four different components of self-reflection. Thus, for these four components, we can attribute a good quality to our assessment tool.

VII. IMPROVEMENT OF MODEL AND ASSESSMENT TOOL

For the core aspects of self-reflection of our initial theoretical model, the results of the combination of factor analysis and reliability analysis indicate that the initial model structure is mirrored only partially by our data set. Rather, instead of the different stages of the self-reflection process, the different *content areas* to which self-reflection is applied are more relevant when distinguishing independent factors. Specifically, those items that were intended to address *abstraction* seem to be only insufficiently selective in the data set.

TABLE V
DESCRIPTIVE STATISTICS FOR THE RELIABILITY ANALYSIS OF THE IDENTIFIED FACTORS FOR SELF-REFLECTION: SIZE OF DATA SET, SCALE LENGTH, CRONBACH'S ALPHA, MINIMUM AND MAXIMUM VALUE, MEAN VALUE AND STANDARD DEVIATION

Scales for core aspects of Self-Reflection	N	Scale Length	Cronbach's Alpha	Min	Max	M	SD
Factor I: situative self-observation and self-awareness	296	7	0.59	2.70	5.00	4.05	0.50
Factor II: self-centered action-oriented situative analysis and abstraction	298	7	0.74	1.71	5.00	3.61	0.64
Factor III: social context oriented situative analysis and abstraction	298	8	0.77	1.71	5.00	3.61	0.64
Factor IV: general self-awareness of disposition	298	5	0.64	2.00	5.00	3.79	0.59

Of course, the effect could be due to an improper selection of items, or to a severe flaw within the initial model. However, it is somewhat conspicuous that all the items for which the factor analysis differs from our initial positioning deal with abstraction. To clarify this, we analyse the level of abstract thinking skills and concrete thinking skills within our test group and correlate it to the results of our self-reflection assessment.

A. Relevance of Abstract Thinking Skills

Greif stated 2008 that most people are lacking in meta schema or meta patterns for creating systematic reflections. Instead, they merely mull over striking characteristics and only for a rather short period of time. Especially when reflecting on complex issues, this limits the amount of findings and thus the degree of enlightenment that can be reached [12, p. 41].

In principle, meta schemes and meta patterns are results of an abstraction process. Furthermore, they cannot be developed, or even understood, without sufficient abstract thinking skills. Therefore, the above statement of Greif supports our assumption that limitations in the *abstract thinking competence* of our test persons are at least partially responsible for this phenomenon.

The action day for first semester students, in whose context our test persons underwent our self-reflection assessment, comprised several other assessments as well. One of them focused on technical and methodical competences, especially cognitive competences [13]. Thus, we are able to evaluate the relevant cognitive competences of our test group, i.e., abstract thinking and concrete thinking as its counterpart.

The results of the diagnostic test for cognitive competences indicate that our test cohort struggles significantly more with abstract thinking than with concrete thinking. From our test cohort of size $N = 299$, the number of students that correctly solved test items requiring concrete thinking range from 226 to 235 per item (average: 231.5 out of 299). Thus, 77% of our test persons were able to solve the tasks requiring intermediate skills in concrete thinking. Note that the concise range indicates a certain stability within the skill.

In contrast to this, in tasks requiring abstract thinking skills, our test cohort scored significantly lower. The number of students that correctly solved test items requiring the application of abstract thinking skills onto static content (i.e., results rather than processes) range from 144 to 228 per item (average: 166 out of 299). Thus, merely 55% of our test persons were able to

solve the tasks requiring intermediate skills in abstract thinking on static content.

For the application of abstract thinking on dynamic content (i.e., processes), the our test group shows even less proficiency. Here, only 127 out of 299 students were able to solve the task in question, corresponding to 42%.

Therefore, correlating the results our test group achieved in our self-reflection assessment with their results in the diagnostic test for cognitive competences supports our hypothesis that the results of the self-reflection assessment might be influenced by the comparatively low level of abstract thinking competence of our test group. To validate this hypothesis, we need to run our self-reflection assessment with a test group for which high abstract thinking skills have already been acknowledged.

B. Refining the Model Structure

On the one hand, the results of our factor analysis indicated that the different content areas to which self-reflection is applied are highly relevant when distinguishing independent factors. On the other hand, from the analysis of our test cohort's abstract thinking competences we concluded that the intermingling of analysis and abstraction within the identified factors might to some extent be due to limitations in the test cohort's abstract thinking abilities.

Therefore, when refining our model we uphold the distinction between *situative analysis* and *abstraction* as core aspects of the self-reflection process. Furthermore, we use the identified factors to refine these core aspects with respect to the *content areas* that were identified as relevant in our factor analysis (see Figure 2).

When visualizing this refinement of our model structure, it quickly becomes apparent that our self-reflection assessment entirely omits one aspect of self-reflection – the *self-centered emotion oriented situative analysis*, which is a necessary pre-stage for being able to develop a general self-awareness of disposition on the abstraction level. To explicitly address this area, we have to add additional items into our self-reflection assessment.

VIII. CONCLUSION AND FUTURE WORK

After conceptualizing different aspects of self-reflection from a theoretical perspective as an extension of existing models, we designed and evaluated a corresponding assessment tool that addresses these different aspects.

In order to evaluate our self-reflection assessment tool, we executed both a factor analysis and a reliability analysis. The

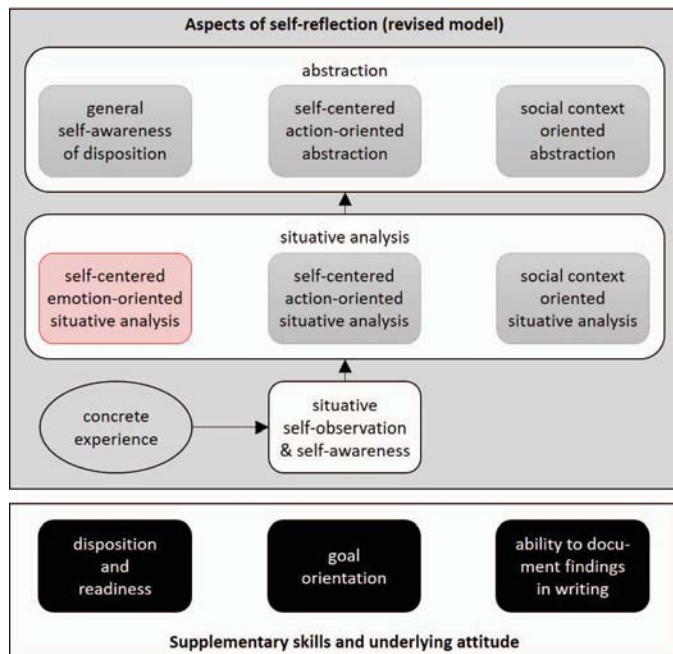


Fig. 2. Revised Model of the different aspects of self-reflection, with supplementary skills and underlying attitude

reliability analysis indicates that our self-reflection assessment tool is well suited to measure both the identified factors on content areas of self-reflection and the supplementary skills and attitude we specified in our theoretical model.

As well, the evaluation suggests that the results of the factor analysis that we ran on our data set might be influenced by the rather low abstract thinking competences of our test cohort.

Critically revising both the model and the self-reflection assessment on the basis of our evaluation results made it apparent that our self-reflection assessment omits an important aspect of self-reflection, the self-centered emotion oriented situative analysis. Therefore, we have to add additional items into our self-reflection assessment, in order to explicitly address this area.

So far, there has been just one assessment at a single point in time. Thus, studies on long term development are not yet possible. However, a sound assessment tool can constitute a basis for long term studies on the development of students' self-reflection skills. Among other things, it enables us to evaluate the effectiveness of interventions for fostering self-reflection skills. As well, it allows us to analyze the relevance of self-reflection for our students' learning process, by relating their self-reflection skills to the study success they achieve.

REFERENCES

- [1] N. Akkuzu. The role of different types of feedback in the reciprocal interaction of teaching performance and self-efficacy belief. *Australian Journal of Teacher Education*, 39(3):37–66, 2014.
- [2] E. M. Anderson, L. M. Bohon, and L. P. Berrigan. Factor structure of the private self-consciousness scale. *Journal of Personality Assessment*, 66(1):144–152, 1996.

- [3] S. Atkins and K. Murphy. Reflection: A review of the literature. *Journal of Advanced Nursing*, 18:1188–1192, 1993.
- [4] D. Boud, R. Keogh, and D. Walker, editors. *Reflection: Turning Experience into Learning*. Routledge, 1 edition, 1985.
- [5] R. E. Burnkrant and T. J. Page. A modification of the fenigstein, scheier, and buss self-consciousness scales. *Journal of Personality Assessment*, 48(6):629–637, 1984.
- [6] J. Dewey. *How We Think: A Restatement of the Relation of Reflective Thinking to the Educative Process*. DC Heath, Boston, MA, 1933.
- [7] D. Dörner. Selbstreflexion und Handlungsregulation: Die psychologischen Mechanismen und ihre Bedingungen (self-reflection and action regulation: Psychological mechanisms and their conditions). In W. Lübbe, editor, *Kausalität und Zurechnung. Über Verantwortung in komplexen kulturellen Prozessen (Causality and accountability. On responsibility in complex cultural processes)*, pages 199–222. Shaker, Aachen, 1994.
- [8] A. Fenigstein, M. F. Scheier, and A. H. Buss. Public and private self-consciousness: Assessment and theory. *Journal of Consulting and Clinical Psychology*, 43:522–527, 1975.
- [9] G. Gibbs. *Learning by Doing. A Guide to Teaching and Learning Methods*. Oxford Brookes Further Education Unit, Oxford, 1988.
- [10] A. Grant, J. Franklin, and P. Langford. The self-reflection and insight scale: A new measure of private self-consciousness. *Social Behavior and Personality*, 30:821–835, 01 2002.
- [11] S. Greif. Selbstorganisierende Prozesse beim Lernen und Handeln. Neue Erkenntnisse aus der Grundlagenforschung und ihre Bedeutung für die Wissensgesellschaft (self-organized processes in learning and doing. new insights from fundamental research, and their relevance in science). Universität Osnabrück, <http://www.psycho.uni-osnabrueck.de/fach/aopsych/Downloads/texte/neuro-sol4.pdf>, August 2000.
- [12] S. Greif. *Coaching und ergebnisorientierte Selbstreflexion (Coaching and result-oriented self-reflection)*. Hogrefe Verlag GmbH, Göttingen, 2008.
- [13] S. Hammer, D. Zehetmeier, A. Böttcher, and V. Thurner. Evaluation of a diagnostic test for cognitive competences that are relevant for computer science. In *IEEE Global Engineering Education Conference (EDUCON)*, pages 622–629, 2018.
- [14] D. Kolb and R. Fry. Toward an applied theory of experiential learning. *Theories of group process*, 01 1974.
- [15] V. Thurner, A. C. Böttcher, and A. Kämper. Identifying base competencies as prerequisites for software engineering education. In *Global Engineering Education Conference (EDUCON), 2014 IEEE*, pages 1069–1076, April 2014.
- [16] P. D. Trapnell and J. D. Campbell. Private self-consciousness and the five-factor model of personality: Distinguishing rumination from reflection. *Social Behavior and Personality and Social Psychology*, 76(2):284–304, 1999.
- [17] D. Zehetmeier, V. Thurner, and A. Böttcher. An action day for first-semester students, fostering self-reflection, networking and many other skills. In *International Conference on Higher Education Advances (HEAD)*, 2017.