Integrating Students' Learning Experiences through Deliberate Reflective Practice

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Abstract - **This paper presents the evaluation of an alternative procedure to facilitate engineering students' reflective learning in the context of situated learning experiences. The procedure takes the format of a focus group with specific triggers to elicit students' accounts of critical learning experiences. This reflection starts from students' concrete, intuitive feelings of consternation when their prior understandings of engineering were challenged by a situation encountered in practice – we call these competence anomalies. The effectiveness of the suggested procedure was evaluated in a survey of 58 engineering students who had participated in trial focus groups. The analysis of the 5 point Likert scale ratings indicated that the majority of students (78.9%) saw significant benefits from their participation. Subsequent questions revealed that the focus groups supported the recall of learning incidents but did not give students enough guidance in interpreting their experiences. For the further development of the tool we thus propose a four step SAID structure (Situation, Affect, Interpretation, Decision). The paper concludes with an outlook on the implementation of this expanded concept as a concurrent reflective tool in an innovative engineering synthesis and design studio series. In this context, the reflection is intended to promote overall integrative learning that encompasses the curriculum, situated learning as well as the students' prior and current life experiences.**

Index Terms - Focus groups, reflection, situated learning

INTRODUCTION

As the practice of engineering is becoming more complex and inherently social [1-4] the need for more broadly educated and holistically thinking [5-8] engineers is commonly recognized. When discussing some of the shortcomings of the current system of engineering education in achieving this goal, a number of authors acknowledge that classroom teaching alone is not sufficient to prepare engineering students for the complex demands of real-world professional practice [9, 10]. A host of initiatives, which we subsume under the term situated learning, particularly in the area of co-operative [11] or service learning experiences [12] and placement programs [13] are attempts to overcome these limitations of classroom-based pedagogies.

In the context of students' development of holistic thinking capacities, this paper focuses on the integrative function of deliberate and guided reflection in connecting students' various experiences outside the classroom with their learning at university. The role and importance of reflection on students' professional [14, 15] and intellectual [16, 17] development has been widely explored both in the area of experiential learning in general [18, 19] and in the field of engineering education in particular [10, 11, 20].

Beyond a consensus of the beneficial effect of reflection on student development [21], it is, however, much less well understood how student reflection can be initiated as a part of engineering programs [11, 22]. The few existing approaches are mostly modeled after reflexive elements in professional development or accreditation systems [13, 23] that were shown to be limited in their effectiveness to promote developmental student reflection [24].

This paper presents an alternative method of eliciting student reflection that was developed in the context of a larger study into engineering students' competence formation and presented in its early stages at a previous Frontiers in Education Conference [24]. After further development, the method was trialed in nine student focus groups with a total number of 58 participants from institutions in Australia, Germany, the United States and Thailand. The students participated in situated learning programs and reflected on the connection of these experiences with their academic curriculum. The following reports the reflective focus group protocol with reference to the previous publication [24] that was focused on the practicalities of facilitating such reflective exercises with engineering students. The subsequent sections present the analysis of data from a survey of the focus group participants that explored the nature and extent of the students' perceived benefits. The paper concludes with a discussion of the possibility of a wider application of the concept in engineering curricula to promote holistic student development.

COMPETENCE ANOMALIES AS TRIGGERS FOR STUDENT REFLECTION

The reflective tool presented here takes the format of a student focus group based on the elicitation and discussion of critical learning incidents. Critical incident techniques [25-27] involve guiding students to recall specific experiences from their situated learning and put these in the context of their prior academic experiences. A particular focus in eliciting these critical incidents is establishing complete accounts of the situation and limiting the initial recollection to what happened or what exactly the individual did in the situation. This is to mitigate the influence of "espoused beliefs" [28] on the account and allows for an

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open-ended interpretation at a later stage when the situation has been comprehensively established.

The semi-structured focus group protocol used to elicit these critical learning incidents is based on the following three mechanisms of initiating student reflection (For more detail see [24]):

- Non specific triggers – competence anomalies
- Specific triggers – interactive incident recall
- Abstract triggers – competence descriptors

The competence anomalies as the initial trigger are the crucial component in overcoming engineering students' difficulties with reflective exercises [22]. During this stage the students are presented with statements that are intended to evoke memories of surprises or turning points in their competence development. Sentences such as "The way that work here is done, is really different from what I was used to doing in college" (For more detail see [24]) are used to prompt students to recall situations when their prior learning and understanding was challenged by new experiences. In these moments significant development in the sense of constructivist learning theories occurred [29, 30] and students also implicitly made connections between the current situated learning experience and their prior learning at university. In one of the early pieces on reflective learning, Dewey [18] describes the same phenomenon as:

> *"In cases of striking novelty or unusual perplexity, the difficulty, however, is likely to present itself at first as a shock, as emotional disturbance, as a more or less vague feeling of the unexpected, of something queer, strange, funny, or disconcerting. In such instances, there are necessary observations deliberately calculated to bring to light just what is the trouble or to make clear the specific character of the problem. In large measure, the existence or non-existence of this step makes the difference between reflection proper, or safeguarded critical inference and uncontrolled thinking."* [18; p. 74].

Targeting these moments of competence anomalies presents students with the opportunity to start their reflection with a concrete, intuitive recollection and relieves them of the pressures of undirected reflection ("What could I possibly reflect on?") and the restrictions of pre-determined reflection ("What could I come up with that would be accepted as an example of my communicative abilities?").

The second stage of the interactive incident recall uses the specific triggers in other participants' accounts to elicit students' recollection of their own specific experiences. This can include experiences of similar nature but also unrelated accounts that were triggered by an arbitrary element in another students' critical incident account. As a facilitator of the focus group it is important to re-enforce this openness of the discussion and explicitly encourage a diversity of contributions.

The third stage of abstract triggers is similar to the reflective portfolio approach [31] used in professional accreditation in that it presents students with abstract competence descriptors. The students are encouraged to recall a specific situation in which they acquired or developed this particular competency. Abstract triggers, however, entail a number of difficulties that limit their usefulness in open-ended formative reflection. Their usage relies on cognitively difficult processes of abstract to concrete inference [32], presents the problem of limiting participants to pre-conceived categories of competence and also poses the danger of incorrect association of an experience with the given competence category. For these reasons, this particular stage of the focus group is only introduced once the other triggers are exhausted in their capacity to elicit new accounts.

EVALUATION OF STUDENT BENEFITS

The reflective tool in form of the semi-structured focus group protocol based on the three types of triggers outlined above was trialed in nine student focus groups with a total number of 58 participants. To evaluate the effectiveness of the tool in eliciting students' reflections on the links between their situated learning experiences and their learning at university, a survey of the focus group participants was conducted.

Survey questions and purpose

The purpose of the survey was to explore the following research question both quantitatively and qualitatively:

What was the nature and extent of students' benefits from participating in the reflective focus groups?

This explicitly included a focus on possible limitations of the proposed method. To address this question, the survey employed both closed and open-ended questions to explore the effectiveness of the reflective exercise for the students' learning.

The first question explored on a general level the students' perception of their benefits from the reflective procedure. The qualitative rating on a five point Likert scale ('no perceived benefit' to 'significant benefits') was complemented by an open question to explore the ways in which students benefited.

The subsequent set of questions explored the two aspects of the students' realizations of significant learning experiences both in the university and in the professional context. The questions focused on the participants' recognition of the impact of their prior learning at university on their professional behavior in the workplace and the associated critical learning experiences in practice (e.g.: Did the focus group help you realize significant learning events during your time in professional practice?)

Another set of questions targeted the extent to which students were able to translate the experiences of competence anomalies into specific changes to their future professional behavior as well as their future learning at university. The purpose of these questions was to determine how much the students' realizations of the inconsistencies between their prior learning and the current experience in practice led them to reconcile these tensions into a coherent understanding of their own competence (e.g.: Will the focus group change aspects of how you act as a professional engineer?). The Likert scale ratings on these items were also combined with open-ended questions to elicit examples of what the students would 'do differently' on the basis of their reflection.

Survey participants

The participants for the focus groups were selected internationally from institutions in Germany, Australia, the United States and Thailand. All students had participated in innovative placement programs at their respective institutions. As part of these structured programs they had spent a minimum of three months working in industry or related fields. The participants were enrolled in the later years of a wide range of engineering programs. Of the twelve disciplines represented in the sample, the majority of students were mechanical (32.8%) and computer systems (18.5%) engineers. The students' age ranged from 18 to 32 with the majority of 64.6% of students in the age group between 18 to 23. Female students represented 35.4% of the sample. The gender ration was not explicitly controlled however a proportion of at least 15% female students was desired to give a balanced representation of the engineering undergraduate population. The survey was given to the students immediately after the focus groups with their participation in the survey being anonymous and voluntary. Out of the total of 58 participants in the focus group the response rate to the survey was 96%.

Survey and analysis methods

The survey consisted of 10-items and utilized a 5-point Likert scale and open answer formats. The Likert scale ranged in all cases from strong disagreement (1) to strong agreement (5) with (3) being neutral.

The authors analyzed the Likert-scale questions using Microsoft Excel. First, the authors determined for each question the average across all respondents. Additionally, the number of responses was displayed graphically with a histogram so that subtleties between the data sets could be seen.

The authors collected the open-ended question responses and entered them into Microsoft Excel, which provided a way to organize the responses during analysis. Illustrative examples of the open-ended survey results were then reported to provide a deeper understanding of the quantitative, Likert-scale responses.

Of the 58 completed surveys, one survey was not included in the results and analysis because the student did not follow the survey instructions and marked two responses for two of the Likert-scale questions.

RESULTS

The following presents the results for each of the questions through a histogram of the response ratings and discusses each in the context of selected quotes from the corresponding open-ended questions.

Student responses to the survey question, "Do you feel you personally benefited from you participation in the focus group?" are presented in Figure 1. These responses indicated that most students felt they benefited personally from the focus group with 78.9% of the students responding in the categories of "I can see some benefits" or "I see a lot of benefits for myself." The average response of this survey was 4.04.

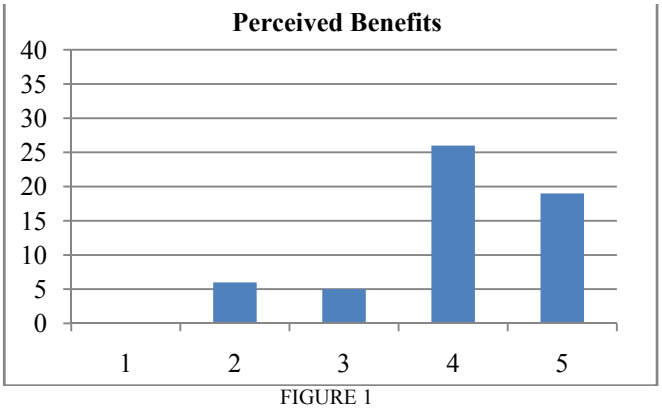

FIGURE 1
NUMBER OF STUDENT RESPONSES TO THE QUESTION, "DO YOU FEEL YOU PERSONALLY BENEFITED FROM YOUR PARTICIPATION IN THE FOCUS GROUP?" LIKERT SCALE RANGING FROM 1-"I DID NOT BENEFIT AT ALL" TO 5-"I SEE A LOT OF BENEFITS FOR MYSELF"

After this question, the student participants were asked, "If so, can you describe in which way?" Of the 57 survey respondents, 52 responded to this question. Illustrative examples of the responses are the following: "It is good to see the different things we have learned without knowing it," "To talk to other students and hear their perspectives is comforting, because I sometimes feel inadequate for engineering," and "I can see some benefits, but I think it would have been better to be more aware of this idea earlier in my studies so I could focus on these tendencies."

Student responses to the survey question, "Did the focus group help you realize new aspects of how your experiences at university influenced your professional engineering competence?" are presented in Figure 2. These responses indicated that most students realized new aspects of how their university experiences influenced their professional engineering competence with 77.2% of the students responding in the categories of "I realized a few new aspects" or "I realized a number of significant aspects." The average response of this survey was 3.82.

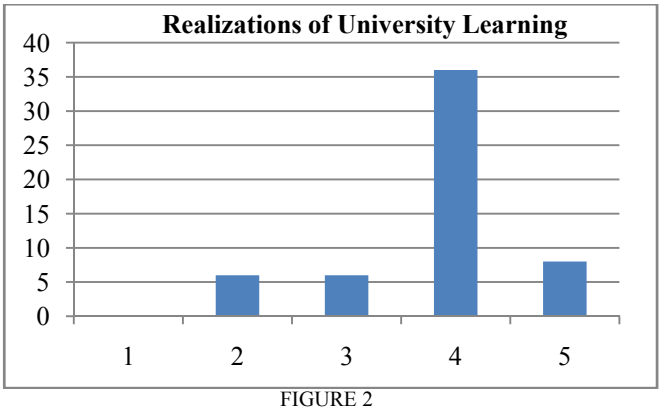

FIGURE 2
NUMBER OF STUDENT RESPONSES TO THE QUESTION, "DID THE FOCUS GROUP HELP YOU REALIZE NEW ASPECTS OF HOW YOUR EXPERIENCES AT UNIVERSITY INFLUENCED YOUR PROFESSIONAL ENGINEERING COMPETENCE?" LIKERT SCALE RANGING FROM 1-"I DID NOT SEE ANY NEW ASPECTS" TO 5-"I REALIZED A NUMBER OF SIGNIFICANT ASPECTS"

Student responses to the survey question, "Did the focus group help you realize significant learning events during your time in professional practice?" are presented in Figure 3. These responses indicated that most students realized

learning events during their professional practice by 80.7% of the students responding in the categories of "I realized a few new aspects" or "I realized a number of significant aspects." The average response of this survey was 4.09.

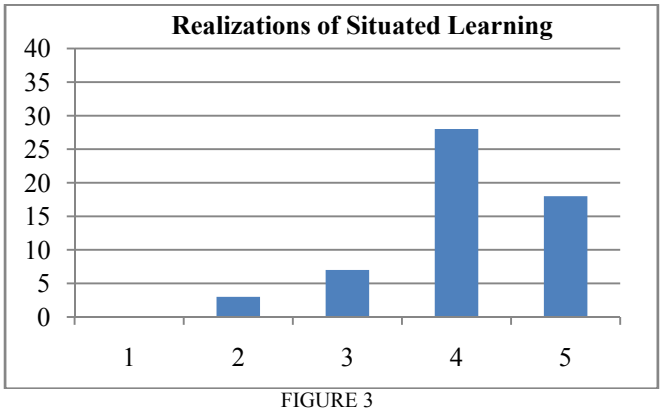

FIGURE 3
NUMBER OF STUDENT RESPONSES TO THE QUESTION, "DID THE FOCUS GROUP HELP YOU REALIZE SIGNIFICANT LEARNING EVENTS DURING YOUR TIME IN PROFESSIONAL PRACTICE?" LIKERT SCALE RANGING FROM 1-"I DID NOT SEE ANY NEW ASPECTS" TO 5-"I REALIZED A NUMBER OF SIGNIFICANT ASPECTS"

Student responses to the survey question, "Will the focus group change aspects of how you act as a professional engineer?"" are presented in Figure 4. These responses indicated that fewer students expect that they will change in their professional work as a result of the focus group by 45.6% of the students responding in the categories of "I think I will change some things" or "I have significant changes in mind." Many respondents (38.5%) indicated that "I have to think more about it." The average response of this survey was 3.36.

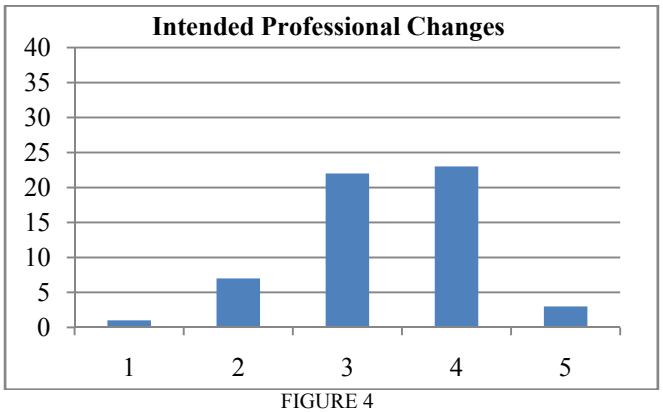

FIGURE 4
NUMBER OF STUDENT RESPONSES TO THE QUESTION, "WILL THE FOCUS GROUP CHANGE ASPECTS OF HOW YOU ACT AS A PROFESSIONAL ENGINEER?" LIKERT SCALE RANGING FROM 1-"I DID NOT TAKE ANYTHING AWAY" TO 5-"I HAVE SIGNIFICANT CHANGES IN MIND"

After this survey question, the student participants were asked, "If so, can you give an example for how you want to change your professional behavior?" Of the 57 survey respondents, 34 responded to this question. Illustrative examples of responses to this question are the following: "Change my take on problems into a positive way (positive thinking)," "Perhaps be more mindful of practical components and ask questions about practical stuff in theory classes," and "Spend some more time on reflection (reflective processes) and keep a log book of these reflections (electronic)."

Student responses to the survey question, "On the basis of your reflection in the focus group: Will you approach your learning at university differently?" are presented in Figure 5. Half (52.6%) of the students felt they benefited personally from the focus group which is a lot less agreement than in the prior questions. The average response of this survey was 3.35.

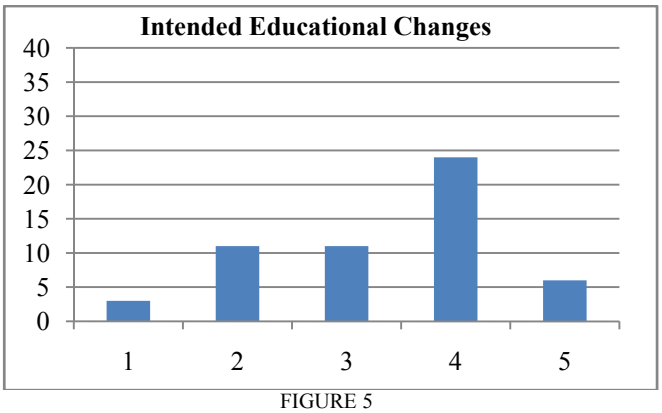

FIGURE 5
NUMBER OF STUDENT RESPONSES TO THE QUESTION, "ON THE BASIS OF YOUR REFLECTION IN THE FOCUS GROUP: WILL YOU APPROACH YOUR LEARNING AT UNIVERSITY DIFFERENTLY?" LIKERT SCALE RANGING FROM 1-"I DID NOT TAKE ANYTHING AWAY" TO 5-"I HAVE SIGNIFICANT CHANGES IN MIND"

After this survey question, the student participants were asked, "If so, can you give an example for of what you will do differently at the university?" Of the 57 survey respondents, 41 responded to this question. An illustrative example of a response to this question is the following: "Try to be more aware of what all the little (but difficult) problems we solve mean in real life. How they could help me in the future."

Finally, the final question on the survey was, " Do you have any other comments/suggestion e.g. for improving future focus groups?" Of the 57 survey respondents, 37 responded to this question. An illustrative example of a response to this question is the following: "I liked the chance to share my feedback and my insight. I think sessions like this might be a good way to get more honest feedback."

DISCUSSION

The following discusses, first, the results of the survey and their implications for the usefulness of the reflective tool presented here and, second, the wider implications of the work and specifically the possible implementation of the reflective procedure in other areas of engineering education. The paper concludes with an outlook on the implementation of the proposed concept in a new engineering program.

Implications of the results

The survey results indicated that the students benefited significantly from their participation in the focus groups. In particular, the use of the three stages of triggers provided them with a starting point for their reflection. Unlike other procedures that start from abstract goals for the reflection,

the students were able to begin their reflection from tangible feeling of consternation when their experiences in practice differed significantly from their expectations based on their prior learning at university. This explains the overwhelming agreement to the categories of questions that targeted the realization of learning aspects.

In addition to an easy associative access to the individuals' memories, the use of competence anomalies also ensures an inherent connection of prior university learning and current situated experience. In the context of promoting students' professional development through situated learning experiences, this connection ensures the integration of situated and prior learning into a coherent "professional way of being" [14] and prevents the students' experience of professional practice to remain separated from their understandings of engineering acquired at university. In the context of fundamental learning theories, the targeted reflection on moments where the students' prior understandings were challenged by a situation in the workplace focuses on the essential process of constructing new knowledge from experience [29, 30].

Beyond the realization of the critical learning incidents, the students did not show an equally consistent agreement when assessing their specific learning outcomes on the basis of the focus group reflection. Having realized the tensions between their prior learning and the experiences during the placement program, the students were not in all cases able to derive a clear intent for changing their future behavior. This indicates that a structured reflection process needs to be explicitly facilitated beyond the recollection of critical learning experiences.

A structured way to achieve this is the use of SAID framework [33] consisting of the four steps of **S**ituation, **A**ffect, **I**nterpretation and **D**ecision. This framework for reflection suggests a process that includes an account of the situation, a description of how the situation personally affected the learner, followed by the analysis of the events in abstract terms and finally the formulation of a decision for changes of behavior or further learning. The description of the situation as well as the affect can be ideally achieved in the focus group concept. The students can share their stories and talk about how they affected them personally and why it was a significant learning experience from their perspective. One student described this mechanism that also contains an element of emotional assurance as:

> *"It was good to exchange experience with friends so we know that problems didn't just happen to me only but to other people as well. Therefore, I don't have to be too stressed about it."*

However the focus group format might not be as conducive to the latter two steps of the SAID framework, which are interpretation and decision. Once the stories of the students' experiences are established it is not a matter of reaching a group consensus of what a certain type of experience generally means, it rather requires a personal understanding of what an incident means for the individual at this particular point in their own professional formation. The focus group's dynamic is likely to prevent some students from arriving at such an individual conclusion. In the trial focus groups it was observed that it was difficult to maintain the focus on the actual incident when entering the stage of abstract interpretation. Students often tended to present their general opinions and preconceptions of university learning or the demands of practice. In the context of a structured reflective development such espoused beliefs are unlikely to promote real learning as they are divorced from the learner's actual experience and behavior. For these reasons we propose a focus group as presented here as a means to elicit students' accounts (Situation and Affect) followed by an individual session of written reflection on the interpretation and decision stages.

Wider application of the concept

The focus groups described here were characterized by the following two elements that could present significant limitations with respect to achieving the full potential benefit for students' learning. First, the focus groups were conducted with a particular focus on situated learning experiences in placement programs, and, second, the reflection sessions were held at one point in time after the students had completed their placement program. These two characteristics were due to the design and context of the larger study. Developing the concept of the reflective tool beyond the two limiting factors suggest the notions of *holistic integrative learning* and of *concurrent reflection*.

A *holistic integrative learning* process across all domains of the students' learning could be supported by explicit and directed reflection as described in this paper. While situated learning experiences form an important part of learning outside the classroom, integrative learning could reach beyond this to include the students' entire experience while at university. It is commonly agreed that a connection needs to be established between situated learning experiences and the students' learning at university. The other aspects of the students' experience that impact on their learning are, however, equally or even more disconnected from their study. The courses of an engineering program are largely isolated in disciplinary silos and the students' prior and current life experiences are entirely divorced from their learning at university. Previous studies [34-36], however, suggest that these aspects significantly contribute to the students' overall competence formation. On the basis of the work presented here we thus contend that integrative learning supported by deliberate and guided reflection needs to link the curriculum, situated learning, and students' current as well as prior life experiences.

Developing the reflective tool beyond the limitations of a one-time after the event mechanism leads to the concept of *concurrent reflection*. The introduction of concurrent reflective exercises into the engineering curriculum, particularly with a view to spanning all aspects of students' experiences, promises a number of inherent advantages. The real-time reflection in, for example, several sessions during a semester potentially improves the participants' recall of critical learning incidents. At the same time, concurrent reflection could follow and promote the gradual development of aspects of students' professional competence. The engagement in regular reflective activity is also likely to develop students' meta-cognitive abilities and thus promote their formation into holistically thinking and broadly educated engineers.

Outlook

To put this concept of concurrent integrative learning into practice, an innovative series of synthesis and design studios [37, 38] is currently being implemented in a new environmental engineering program at the University of Georgia. This four year series of studios involves challenge-based learning activities whereby student groups work towards a concrete and locally implementable solution to an ill-defined problem centered on the topic of sustainability. The reflective exercise based on the focus group and SAID concept with the extension of concurrent reflection and a broader focus on students' entire experience will be integrated into these studios to enhance their integrative function within the curriculum.

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