Evaluating the applicability of Approaches to Teaching Inventory (ATI) in higher engineering education research and development

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***Abstract*— This Work-in-Progress research paper presents the rationale and a plan to evaluate the applicability, validity, and reliability of Approaches to Teaching Inventory (ATI) in higher engineering education research and development. The ATI is a widely used, but also criticized, tool in higher education research in different disciplines, including engineering. This paper discusses the validity and reliability of the ATI as an instrument in general, and the applicability of the ATI in the discipline of engineering. A research plan to scrutinize the validity, reliability, and applicability of the ATI in engineering education is proposed, and the FIE community is invited to offer their expertise in developing and executing the plan.**

Keywords—Approaches to Teaching Inventory, content validity, construct validity, reliability, engineering education research

I. INTRODUCTION

A. Development of ATI

Approach to Teaching Inventory (ATI) is an instrument developed in the 1990s by Keith Trigwell and Michael Prosser [1] to measure the "key aspects of variation in approaches to university teaching" in order to relate them to the students' approaches to learning. The creation of the inventory originated from a phenomenographical study, where five qualitatively different approaches to teaching were discovered based on interviews of 24 university science teachers. The five categories exhibited four different intentions behind teaching (information transmission, concept acquisition, conceptual development, and conceptual change) and three different teaching strategies (teacher-focused, student-teacher interaction, and student-focused). During the construction of the inventory, three of the original five categories were dismissed resulting in a survey with 16 statements scoring the respondents on two scales: the Information transmission/Teacher-focused (ITTF) and the Conceptual change/Student-focused (CCSF) approach scale. Both scales were composed of the subscales of intention and strategy.

B. Current use of ATI

Currently, the ATI is a widely used tool in higher education research and development. In addition to the original intent of relating the teachers' teaching approaches and the students' learning approaches, it has been used, for example, to measure and explain teachers' repertoire of teaching methods [2], to evaluate the impact of pedagogical training on teachers' conceptions [3], to study the development of teacher identity [4], and to understand the variety of teaching conceptions [5]. Although the instrument was originally developed in the contexts of science teaching, it has been applied in various disciplinary contexts, and also used to understand the disciplinary variation in teachers' thinking [5–8]. In engineering, the ATI has been applied at least to develop training in university pedagogy [9], to understand the diversity of academic community [10], to explore the impact of pedagogical training [11], to examine the relationship between beliefs and practices [12, 13], and to examine university students' approaches to learning [14].

C. Applicability of the ATI to engineering education research

However, the applicability of the instrument to engineering education remains somewhat unclear. The validity of the instrument has been challenged [15], and the development process and applicability have been criticized [16]. The results regarding disciplinary variation are contradictory, with some studies showing evidence on disciplinary differences [6, 7], and some not [8]. In addition, many of these studies included no engineering teachers, or the studied disciplines were clustered in such a way that it was not clear whether engineering was among the disciplines under study. Hence, it is difficult to evaluate the generalizability of the findings from the ATI studies in other disciplines to engineering.

First, this paper discusses the validity and reliability of the ATI based on previous research and draws attention to some important issues. After that, the paper presents a plan to empirically investigate the issue further. As a work-in-progress research paper, it also invites the engineering education research community to comment on the assumptions on which the research scheme is based, and suggest improvements in the research plan.

II. VALIDITY AND RELIABILITY OF ATI

Validity of a research instrument is a multifaceted issue, and there appears not to be an agreement on a common conceptualization or a theory of the subject. This paper follows the footsteps of Cronbach and Meehl [17] and discusses validity from the viewpoints of content validity, criterion validity, and construct validity. Reliability is viewed mainly from the aspect of internal consistency.

A. Evaluating different types of validity

Criterion validity is evaluated by obtaining a criterion measure independent of the instrument applied to the same subjects and computing a correlation between them [17]. If the independent criterion measure is obtained after the use of the instrument, the validity is called predictive, and if the measures are obtained at the same time, the validity is said to be concurrent [17]. Construct validity can be described as the fit between the instrument and the (theoretical) construct that the instrument is measuring. Lissitz and Samuelsen [18] interpret Cronbach and Meehl's conceptualization of construct validity to include two aspects: a study of the construct to be measured, often referred to as structural validity, and its relationship to other constructs, that is, a nomological network. The construct validity is typically studied with various statistical methods [see e.g. 15, 18].

Sireci and Faulkner-Bond [19] define content validity as "the degree to which the content of a test is congruent with testing purposes" and suggest that it consists of four elements: domain definition, domain representation, domain relevance, and appropriateness of test construction procedures. For a test to have good content validity, it has to describe in detail what the test measures, the test items have to represent the whole domain and be relevant to the targeted domain, and the test development process has to be such that it supports the representativeness and relevance of the test [19]. The content validity of an instrument is commonly obtained by collecting and analyzing the views of external and independent subject-matter experts [19].

B. Criticism of the validity and reliability of the ATI

Meyer and Eley [16] strongly criticize the rigor and methodology adopted in the development of the ATI and argue that it represents "a methodologically-flawed and conceptually-limited framework to approaches to teaching." They also draw attention to the fact that although the developers of the ATI originally suggested no generalizability of their findings to disciplinary contexts other than first-year university science teaching, they rarely refer to the discipline of the interviewees of the original phenomenographic research [16]. Harshman and Stains [15] discovered that the empirical evidence supporting the original two- and four-factor structures of the ATI were not reproducible, found alternative empirically viable models, and suggested that the measurement of the approaches to teaching should be developed further. These findings indicate that both the content and construct validity of the ATI require attention.

The research findings on the reliability of the ATI vary across settings. Prosser and Trigwell [20] analyzed more than 1000 university teachers' responses and discovered that the scale reliability was acceptable for the 2-scale inventory structure, but not for the 4-scale structure. In some studies using the 2-scale structure, the reliability of the CCSF scale was acceptable but the reliability of the ITTF scale was not [11, 21]. In the literature review part of the study by Harshman and Stains [15], Cronbach's alpha for the CCSF scale was noted to be over 0.7 slightly more often than Cronbach's alpha for the ITTF scale. However, over half of the studies in the review reported no evidence of the reliability or validity [15].

III. ATI IN ENGINEERING EDUCATION RESEARCH

A. Engineering education in the light of the ATI

In the disciplinary variation studies, engineering is usually defined as a hard applied science [22]. Lueddeke [6] suggests that "staff teaching hard/pure or applied subjects are more likely to bring an ITTF orientation to their teaching, while staff teaching soft/pure or applied subjects generally take a more developmental (constructivist) approach in classroom situations (i.e., CCSF)." Nevgi et al. [7] discovered disciplinary differences between hard and soft disciplines, but no differences between pure and applied disciplines. In their data, there was no statistically significant difference between the ITTF and CCSF scores of teachers from hard disciplines, whereas the teachers from soft disciplines were significantly more student than teacher focused. This study, however, included no engineering teachers. However, Stes et al. [21] used the same classification of disciplines and found no relationship between the CCSF scores and the discipline of teaching.

Recent studies using the ATI and focusing solely on engineering teachers suggest that the engineering faculty have stronger CCSF than ITTF orientations [9, 10, 13]. Results regarding the relationship between engineering teachers' approaches to teaching and classroom practices are more mixed: in some occasions, no significant correlation is found [13], and in others, the correspondence between beliefs and practices is close [12]. Andersson and Pears [11] demonstrate a rise in the CCSF score and a decline in the ITTF score among staff completing courses in engineering and science education. A similar development was discovered by Postareff et al. [3], but only after the teachers had had over a year of pedagogical training. Teachers with less than a year of pedagogical training scored lower in the CCSF than teachers with no pedagogical training [3].

B. Epistemological compliance of the ATI

Beliefs about the nature of knowledge and knowing (epistemic beliefs) have been shown to influence learning in several ways [23]. However, having more constructivistic epistemic beliefs will not guarantee the setting of epistemic aims or achieving epistemic gains, as the epistemic motivation, utility value of a task, interest in the problem, beliefs about the context, and perceived expectations of the instructor also affect the way an engineering student approaches a problem solving task [24].

Epistemic beliefs are suggested to have an underlying dimensionality common to all disciplines and disciplinary variation within that framework [25]. The same students expressed different epistemic beliefs regarding psychology and physics [25], indicating that in addition to personal epistemic development, the students' beliefs are affected by the epistemology of the discipline. The ways community proposes, communicates, justifies, assesses, and legitimizes knowledge claims are called epistemic practices [26]. They affect how knowledge enters the educational discourse and influences investigation, explanation generation, and evaluation of knowledge claims also in teaching [26]. Cunningham and Kelly [26] have identified 16 epistemic practices of engineering and classified them into four categories: engineering in social contexts, uses of data and evidence to make decisions, tools and strategies for problem solving, and finding solutions through creativity and innovation. They conclude that education needs to take into account that both propositional and procedural knowledge in engineering are often contextual and developed through application.

The ATI has been suggested to draw on outdated assumptions about the teaching environment and academic staff values [11]. Meyer and Eley [16] point out that in some disciplines, like physics, learning is more a matter of accumulating range than changing conceptions. Niiranen and Naukkarinen [9] draw attention to the wording of the ATI statements and especially the leanings in different forms of discussion as an indication of student-centeredness. They suggest that with many engineering topics, activating the students' thinking is more naturally achieved by giving them practical problem-solving tasks than having them discuss or debate. Teachers' pedagogical understanding and use of various teaching methods is closely related to how they perceive the best way to encourage students to learn [14] as well as their own epistemic beliefs. Hence, the compliance between the epistemic assumptions embedded in the ATI statements—which are at no point discussed by the developers—and the epistemic beliefs held and practices used by engineering teachers is a crucial element of the applicability of the ATI in engineering education. Even if the content validity of the ATI sufficiently matches the epistemology of engineering, it is still worth stopping to think about how the ATI could and should be used in a way that does not contribute to the "false dichotomy between teacher- and student-centered approaches in the engineering classroom" [27].

IV. Plan to Investigate the Validity and Reliability of the ATI in Engineering Education Research

A. Research questions

The literature poses several important questions related to the validity and reliability of the ATI. The crucial issues concerning the content validity of the ATI are "What does the ATI really tell us about the approaches to teaching?" and "Does the ATI reflect the full domain of teaching approaches in engineering education?" Although the factor structure of the ATI has been noticed to be problematic from the viewpoint of construct validity, it poses a challenge also to the content validity. Namely, is the combination of an epistemological stand (how the concept of knowledge and the process of its acquisition are perceived) and a behavioral strategy (whose actions are in the focus) a given one, and does the two-factor solution thus have theoretical grounds?

The construct validity of the ATI assesses the support for different factor solutions in engineering from the empirical viewpoint. The original ATI had two main scales and four subscales, but other empirically viable factor solutions have been found also in engineering education studies. How much is the factor structure of the ATI dependent on the analysis method applied, and what kind of effect different corrections have on it? How does the information received through the ATI change along with the different factorizations (i.e., how the clustering of teachers is affected by changes in the ATI structures)? The questions of construct validity relate closely to the reliability of the ATI in different cases.

Although the criterion validity may not be the most applicable measure for the validity of a rather abstract construction like approaches to teaching, there are some indications that there might be problems also with this. Especially the contradicting results of the of correlation between ATI results and teaching practices measured by other means such as the Reformed Teaching Observation Protocol (RTOP) [12, 13] lead to think about the possibilities to evaluate the criterion validity of the ATI.

The presented study plan aims at an informed decision about the applicability of the ATI to engineering education and understanding the possible limitations for the use of the ATI in engineering education research contexts. The aim is operationalized with three research questions:

1) Can the ATI be regarded as a valid and reliable research instrument in the context of engineering education?

2) What kinds of limitations (if any) are there for the use of the ATI in engineering education research, and where do they originate from?

3) How could the ATI be developed to better meet the needs of engineering education research?

As is evident from the formulation of the research questions, the plan holds a presumption that the ATI, as it is now, has weaknesses as an instrument for engineering education research. This is based on the criticism and development recommendations from other researchers [11, 15, 16] and personal concerns regarding the compatibility of the ATI and epistemic features of engineering.

B. Research methods

The studies of construct validity and reliability will be conducted statistically based on the data combined from [9] and [10], which will be supplemented with some new data. The data will be quantitatively analyzed with exploratory and confirmatory methods and the results compared with previous studies [see 15 for a review]. Special attention will be paid to the criticism of some choices made in the statistical analysis of the original ATI development process [16].

The inspection of the content validity of the ATI in engineering education will be carried out with a literature study and empirical inquiries. A concept analytical literature study of the epistemic beliefs, epistemic cognition, epistemic motives, and epistemic practices in engineering can provide a framework against which the ATI statements should be compared to see if the assumptions related to knowledge and knowing embedded in the statements are in line and adequate in engineering education.

A viable option for empirical approach is to replicate the practice of Faber, Vargas, and Benson [23] and to invite new respondents to provide a written explanation of their response choices. The content analysis of the comments has the potential to reveal variation in the interpretation of the statements (domain definition), as happened in [23], but also to provide some indication of the domain representation and relevance. Another option is to invite a group of subject matter experts in engineering education to evaluate the ATI statements. The experts can be asked for example to rate the statements in terms of their representativeness and relevance, to make pairwise comparisons of the similarity of items, and to match the statements to their respective scales or subscales [19].

The FIE community is very welcome to comment upon and provide knowledge on any issue mentioned in this paper. Help is requested especially in finding the engineering education studies and researchers with previous use of the ATI and identifying the subject matter experts to be invited to participate in the study.

REFERENCES

[1] K. Trigwell, and M. Prosser, “Development and use of the approaches to teaching inventory,” *Educ. Psychol. Rev.*, vol. 16, no. 4, pp. 409–424, 2004.

[2] M. Coffey, and G. Gibbs, “Measuring teachers’ repertoire of teaching methods,“ *Assess. Eval. High. Educ.*, vol. 27, no. 4, pp. 383–390, 2002.

[3] L. Postareff, S. Lindblom-Ylänne, and A. Nevgi, “The effect of pedagogical training on teaching in higher education,“ *Teach. Teach. Educ.*, vol. 23, no. 5, pp. 557–571, 2007.

[4] A. Nevgi, and E. Löfström, “The development of academics’ teacher identity: Enhancing reflection and task perception through a university teacher development programme,” *Stud. Educ. Eval.*, vol. 46, pp. 53–60, 2015.

[5] A. Stes, and P. Van Petegem, “Profiling approaches to teaching in higher education: a cluster-analytic study,” *Stud. High. Educ.*, vol. 39, no. 4, pp. 644–658, 2014.

[6] G.R. Lueddeke, “Professionalising teaching practice in higher education: a study of disciplinary variation and ‘teaching-scholarship’,” *Stud. High. Educ.*, vol. 28, no. 2, pp. 213–228, 2003.

[7] A. Nevgi, S. Lindblom-Ylänne, and L. Levander, “Tieteenalakohtaiset erot opetuksellisissa lähestymistavoissa,” [Disciplinary differences in approaches to teaching] *Yliopistopedagogiikka*, vol. 16, no. 2, pp. 6–15, 2009.

[8] A. Stes, S. Maeyer, and P. Van Petegem, “Approaches to teaching in higher education: Validation of a Dutch version of the Approaches to Teaching Inventory, “ *Learning Environments Research,* vol. 13, no. 1, pp. 59–73, 2010.

[9] S. Niiranen, and J. Naukkarinen, “Developing university pedagogy in engineering higher education, “ in *Proc PATT 37*, Malta, 2019.

[10] U. Beagon, and B. Bowe, “A demographic picture of academics teaching on engineering programmes in Ireland and their approaches to teaching (ATI),” in *Proc Sefi Annu. Conf.*, Budapest, 2019.

[11] S. Andersson, and A. Pears, “The impact of academic staff development on their approach to teaching and learning, “ in *Proc. ASEE Annu Conf.*, Columbus, OH, USA, Jun 2017.

[12] J.A. Middleton, S.J. Krause, K.R. Beeley, E. Judson, J. Ernzen, and Y.-C. Chen, “Examining relationships and patterns in pedagogical beliefs, attitudes and classroom practices for faculty of undergraduate engineering, math and science foundational courses,” in *Proc. ASEE Annu Conf.*, Seattle, WA, USA, Jun 2015.

[13] L. Ross, E. Judson, S.J. Krause, C.J. Ankeny, R.J. Culbertson, and K.D. Hjelmstad, “Relationship between engineering faculty beliefs & classroom practices,” *Proc. ASEE Annu Conf.*, Columbus, OH, USA, Jun 2017.

[14] L., Postareff, P. Nokelainen, and A. Parpala, “Examining university students' approaches to learning with Bayesian nominal indicator modeling,” Manuscript submitted for publication.

[15] J. Harshman, and M. Stains, “A review and evaluation of the internal structure and consistency of the Approaches to Teaching Inventory,” *Int. J. Sci. Educ.*, vol. 39. no. 7., pp. 918–936, 2017

[16] J.H.F. Meyer, and M.G. Eley, “The Approaches to Teaching Inventory: A critique of its development and applicability,” *Brit. J. Educ. Psychol.*, vol. 76, no. 3, 633–649, 2006.

[17] L.J. Cronbach, and P. E.Meehl, “Construct validity in psychological tests,“ *Psychol. Bull.*, vol. 52, 281–302, 1955

[18] R.W. Lissitz, and K. Samuelsen, “A suggested change in terminology and emphasis regarding validity and education,” *Educ. Res.*, vol. 36, no. 8, 437–448, 2007.

[19] S. Sireci, and M. Faulkner-Bond, “Validity evidence based on test content,” *Psicothema*, vol. 26, no. 1, 100–107, 2014.

[20] M. Prosser, and K. Trigwell, “Confirmatory factor analysis of the Approaches to Teaching Inventory,” *Brit. J. Educ. Psychol.*, vol. 76, no. 2, 405–419, 2006.

[21] A. Stes, D. Gijbels, and P. Van Petegem, “Student-focused approaches to teahing in relation to context and teacher characteristics,” *High. Educ.*, vol. 55, no. 3, 255–267, 2008.

[22] T. Becher, “The significance of disciplinary differences,” *Stud. High. Educ.*, vol. 19, no. 2., pp. 151–161, 1994.

[23] C. Faber, P. Vargas, and L. Benson, “Measuring engineering epistemic beliefs in undergraduate engineering students,” in *Proc IEEE FIE*, Erie, PA, 2016.

[24] C. Faber, and L.C. Benson, “Engineering students’ epistemic cognition in the context of problem solving,” *J. Eng Educ.*, vol. 106, no. 4, 677–709, 2017.

[25] B.K. Hofer, “Dimensionality and disciplinary differences in personal epistemology, “ *Contemp. Educ. Psychol.*, vol. 25, no. 4, 378–405, 2000.

[26] C.M. Cunningham, and G.J. Kelly, “Epistemic practices if engineering for education,” *Sci. Educ.*, vol. 101, no. 3, 486–505, 2017.

[27] J.M. Case, “A third approach beyond the false dichotomy between teacher- and student-centered approaches in the engineering classroom,” *Eur. J. Eng. Educ.*, vol. 44, no. 5, 644–649, 2019.