



Developing a Dual Approach, Convergent, Self-Validating and Self-Correcting Scheme for the Assessment of Affective Domain Attributes

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Abstract

Since affective attributes, such as motivation, curiosity, honesty, etc., are vital for effective graduates; hence gauging these attributes effectively at various stages of a degree program can allow an institute to perform continuous quality improvement (CQI) of its learning environment and teaching activities. Purely self-report-based assessment provides a single approach of measurement, which may be prone to issues e.g. social desirability bias. The current effort attempts to develop a novel survey framework comprising two approaches, which are self-reporting and scenario-based questioning, respectively based on iceberg model of systems thinking and Process-Person-Context-Time (PPCT) model of Bronfenbrenner's bioecological systems theory. For a sound implementation of this framework, both approaches largely need to converge (for individual students, within an allowed tolerance) to a single measurement of the latent affective attribute, thus lowering the probability of a bias-contaminated final evaluation. An initial test of the proposed framework was performed via developing a pilot survey instrument administered to a small number (N=22) of undergraduate students of electrical engineering degree program. Subsequent factor analysis of resultant data indicated an overall convergence for the dual approaches; also Bland-Altman plots (and relevant numbers) were used to detect outliers in the data, which were then resolved. In general, the dual approach scheme presented herein may hold the potential to enhance confidence in the affective attribute evaluation of a student cohort, hence subsequent CQI measures can be more helpful for the graduates as well as the society at large.

Keywords: affective attributes, iceberg model, ppct model, surveys, systems thinking

1 Introduction

A sound affective aspect (or the lack thereof) can be a critical factor of any education program as Lynch et al. (2009) say that "knowledge and skills alone do not imply their right use" and Kuo et al. (2024) mention that the neglect of affective domain (AD) leads towards the creation of "graduates ill-equipped in social engineering skills, devoid of social

responsibility, and bereft of affirmative attitudes”. The affective domain, one of the three overlapping domains of Bloom’s Taxonomy, deals with feelings, behaviour, values and related constructs, which are part and parcel of education, as well as professional life. Prada Núñez et al. (2024) say that “positive emotions, such as interest and curiosity, can stimulate active participation and the desire to explore new concepts” and “negative emotions, such as anxiety and boredom, can be significant barriers in the learning process”. In regards to motivation, Muñoz-Merino et al. (2014) say that “[m]otivation is a key factor in the learning process”. The dual approach convergent (DAC) survey framework presented herein, can be implemented by a teacher to gauge an affective trait (e.g. satisfaction with an ongoing course, motivation level, etc.) of their class to perform a subsequent classroom specific CQI. Furthermore, affective attributes measured at various stages, may be used for CQI in effective policy making and for adjusting a school environment. A congenial environment delivering a feeling of belonging may be essential for learning, as Liqueste et al. (2025) say that “[c]reating inclusive learning spaces where all students feel seen, supported, and valued is essential to building a sustainable and diverse engineering profession”.

2 The Need for Dual Approach Convergent Survey

Various instances (e.g. Camelia et al. (2018) and Prada Núñez et al. (2024)) of self-reporting-questionnaire based assessment for affective attributes, may be found in literature. Pekrun (2020) states that self-reporting is “indispensable” for the “assessment of mental processes, including students’ motivation, emotions, cognitive strategies...”. However in the same article, the author mentions various limitations of self-reported assessment, including the usage of language (“there can nevertheless be differences in semantic understanding across cultures and learners”) and emotions (“whenever self-report touches issues that are personally important, emotions are likely to be aroused” and “[i]t is reasonable to assume that these emotions can substantially influence self-report responses”).

Moreover, Jesiek et al. (2020), who develop a scenario-based (situational judgement) test, advocate their approach and object the self-reporting method in the words: “[o]ur results also raise questions about the utility of self-rating scales for measuring professional and other competencies”. As regards scenario-based assessment, (Davis et al., 2023) describe it as “[a]n alternative [to self-reporting], less-common, assessment approach”. Adetayo (2014) mentions, in relation to self-reporting questionnaires, that “...some items may be misunderstood or the respondents may fake their behaviours, a situation that puts the validity and reliability of the results in doubt”. Therefore, we may say that various responses may be contaminated by one or more issues, thus distorting the true measurement of the latent affective variable.

For instance, social desirability is an issue which has received significant attention in the past; various approaches, such as the ones mentioned by Kwak et al. (2021) and Alexander et al. (2025) have been proposed. The current work attempts to mitigate this issue (and other biases, such as common method bias) by proposing the use of a duo of approaches for gauging the same latent affective attribute. The notion of using more than one method has existed as far back as Campbell & Fiske (1959), who developed the multitrait-multimethod matrix validation scheme, and whose work suggests that convergence among more than one method is an indication that the component which is common in the measurements may be attributed to the trait being gauged.

Nevertheless, Campbell & Fiske acknowledge the fact that the measurement methods “make very large contributions to psychological measurements”, hence arises the need of a scheme

to harmonize the two methods of the DAC framework, as well as the significance of the self-correcting feature of this framework which is described subsequently.

The DAC scheme attempts to address the issue of partial contamination (i.e. the case where some of the responses are biased) by disregarding that response which may be contaminated as it is not congruent to the other responses of that surveyee (self-correcting feature). Also, in case of significant contamination in responses of one approach by a surveyee, the convergence criterion will not be fulfilled (self-validating feature). Lastly, the peer-assessment based instrument, attempts to discourage a significant holistic contamination of survey responses in both approaches.

The two approaches of the DAC scheme are self-reporting (SR approach) and scenario-based questioning (vignette approach); respectively rooted in the iceberg model of systems thinking and the Process-Person-Context-Time (PPCT) model of Bronfenbrenner's bio-ecological theory. Both of these models have been regarded as a potential duo, for the delivery as well as analysis of affective domain attributes by Dastgeer & Kalam (2025). As the measurement from both approaches needs to converge, hence, overall, the probability of accurately gauging the latent affective attribute may be improved, as compared to the case of a single approach based measurement.

2.1 Contribution, Scope and Research Questions

The current article serves as a broad, framework-development paper, with major focus towards encompassing various methodological aspects of the DAC scheme. The primary contributions are to introduce the broad architecture of the DAC scheme which includes its theoretical foundations in iceberg model of systems thinking and PPCT model of Bronfenbrenner's bioecological systems theory, the methodology of item development having a focus on cost balancing, and the scoring procedure which leads to final respondent categorization. Alongside these, the current article also hints a feature of resilience towards design weakness, for the DAC framework, which can be helpful in adopting this tool. The empirical component of this study presents a pilot exploratory implementation based upon a single administration to a small set (N=22) of respondents. While this serves to provide a preliminary demonstration of operational feasibility for the DAC framework; it does not provide final psychometric validation of the DAC scheme. Future studies, exploring depth of various facets of the DAC scheme can provide comprehensive psychometric evaluations of this framework.

This work addresses the following interrelated framework-development research questions.

- RQ1: How can direct self-assessment and scenario-based questioning, respectively based upon iceberg and PPCT models, be integrated into a single framework which gauges the same latent affective attribute?
- RQ2: How can cost balancing be utilized to posit similar psychological burden for the two approaches which intend to measure the same affective attribute?
- RQ3: How can contextual as well internal influencing factors be accounted for, which tend to undermine a genuine measurement of the latent affective attribute?

Furthermore, as regards the pilot empirical work, we may add another research question.

- RQ4: Does a small scale pilot implementation of the DAC scheme indicate that it is operationally feasible i.e. it can categorize a majority of student cohort with (DAC specific) convergence of the two approaches?

3 Methodology: Developing the Dual Approach Convergent Survey

The DAC survey's twin approaches have three queries each, which individually place a respondent in one of three levels (bottom, medium, top – BMT, coded as 1,2,3 respectively) in regards to the affective attribute. Subsequent to administering the survey, ω scores (ω_{SR} and $\omega_{Vignette}$) are calculated which are the cumulative (& scaled back to three) sum of each approach for every respondent. ω_{SR} and $\omega_{Vignette}$ are then averaged up (for convergent cases only) to determine the final standing ζ of each surveyee, as regards the latent to-be-gauged affective attribute (hereafter assigned the symbol α). ζ ranges from 1–3; a range that may be flexibly segmented (as discussed in section 4.1) into five categories which are Low, Medium Low (M. Low), Medium, Medium High (M. High) and High. Consequently, a surveyee is placed (if convergence is present) in one of these five categories.

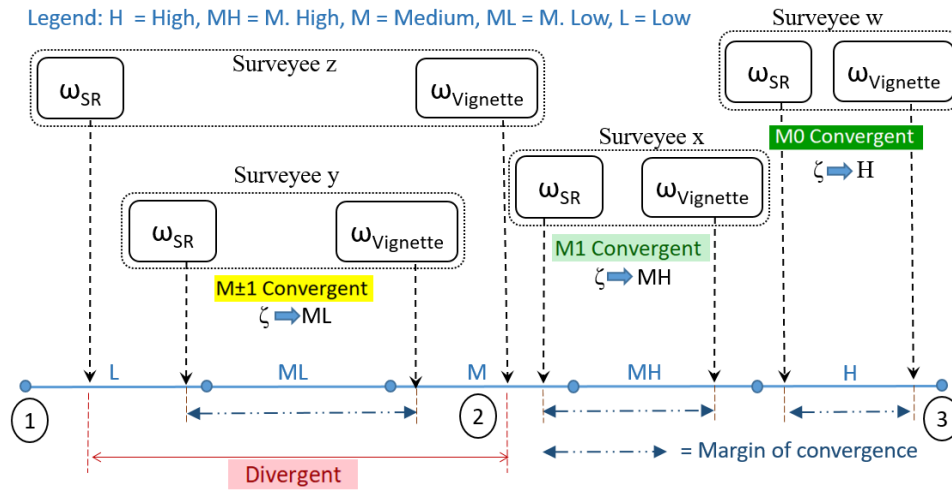


Figure 1. Illustrative examples of convergence and divergence

For convergence, the category decided via final score ζ , needs to be at a maximum margin/distance of only one category, from each of the categorizations, based upon ω_{SR} and $\omega_{Vignette}$. This is hereby termed M±1 convergence. Fig. 1 shows an example for this scenario, where a respondent (surveyee y) is placed in M. Low category, also illustrated are the better scenarios of M1 convergence (where ω scores place a student in adjacent categories) i.e. a margin of one category, and M0 convergence (where both ω scores place the student in the same category) i.e. zero margin in categorization. In Fig. 1, margin of convergence (MC) is the numerical difference between ω scores of a surveyee; the maximum allowable value for the margin of convergence (MMC) is set as one-third portion of the number line (numerically = 0.67). This value stems from allowing at most, two single-step differences in cross-approach ω scores.

Furthermore, for the conducted pilot study, a sensitivity analysis of this maximum margin of convergence w.r.t number of convergent classifications is presented in appendix B; the analysis shows that modifying MMC from 0.67 to 0.33 (least non-zero margin) or 1.00 (loose margin) did not invert the main objective of being able to categorize a majority of the student cohort. It should also be noted that a certain MMC may always be required to cater for issues of language, surveyee emotions, idiosyncratic responses, and for the issue of perception (discussed subsequently). Lastly, all such cases are classified as divergent where mutual difference of ω scores is more than MMC value (e.g. surveyee z in Fig. 1), or if ω scores place a respondent more than one category apart.

In order to implement the DAC scheme, a survey designing teacher (who intends to gauge an affective attribute of their class), needs to achieve a balance of the cost aspect; Song et al.

(2023) quote a description of cost as “the perceived negative consequences of engaging in a task”. Beymer & Schmidt (2023) differentiate between anticipated and experienced cost and say that “[a]nticipated costs refer to one’s anticipated or expected negative appraisals of what must be given up or what is required to complete a given task”. The DAC methodology necessitates that the perceived/anticipated cost for items of one approach should be nearly equal to that of the items of the second approach. However, perception is subjective, as Friedman (2022) says in the article “All is Perception” that “...any two individuals are not guaranteed to form the same representation of an object...”.

Hence, while the DAC survey designing teacher balances the item costs of the dual approaches, as per his/her perception; this perception is not necessarily the same as that of every surveyee; consequently, a certain MMC is required. Furthermore, for the cost aspect, three dimensions may be used, namely effort cost, opportunity cost and emotional cost, respectively described as: the perceived effort which will be required for a task, anticipated “[l]oss of [v]alued [a]lternatives” and perceived “psychological state that results from effort for the task” (Flake et al., 2015).

Developing a new DAC survey contains an optional, but recommended, inclusive student survey stage, which administers a newly developed survey to a small sample (e.g. 2-3 students) from the target surveyees and make any final adjustments to queries. The overall DAC scheme has two instruments: self-assessment survey and the peer-assessment survey. The former, simply referred to as the DAC survey, is the primary instrument, intended for the majority (~85–90%) of the surveyees. The latter, derived from the former by changing the context from self-reporting to reporting about a class fellow, is not utilized as an additional measurement item, rather it only serves as a behavioral intervention tool, intended to discourage deliberate dishonesty/bias in the self-assessment instrument. The present work developed a DAC scheme to gauge the traits of supportive attitude ($\alpha_{\text{Supportive-A}}$) and student motivation ($\alpha_{\text{Motivation}}$) which may be described as ‘a mindset to help and encourage others, especially during challenging times’ and ‘a passionate pursuit of learning’ respectively.

The surveys were administered (online via Google Forms) to final year students of electrical engineering program at the authors engineering school, in the first half of August, 2025, at which point summer vacation was going on. The choice of attributes was illustrative, however it does have a relevance with the students’ group-based capstone project (also called as final year design project – FYDP) for which the students had made their groups and they were supposed to actively pursue their FYDP immediately after the end of the vacation, which also marks the commencement of their 7th semester. An invitation for the survey was sent to 30 students (subsequent to involving 2 additional students, with their consent, for inclusive student survey stage); among these 30 students, 26 responded in time, provided their consent and took the survey. Among these, 4 students (~15% of total) were assigned peer assessment instrument while 22 students (~85%) completed self-assessment survey. Also, an approval was obtained for this work as it involved human participants. Designing of queries is described subsequently.

3.1 The Self-Reporting (SR) Approach Rooted in Iceberg Model

The SR approach poses three queries – two, based upon the mental model (MM) layer and the third based upon systemic structures (SS) layer of the iceberg model of systems thinking. These layers have respectively been linked to affective attributes and (a student’s) system of habits, by Dastgeer & Kalam (2025). The first MM query directly demands self reporting of α , while the second needs to enquire about the presence of such an allied affective attribute which can be deemed as a must-present, if α is present i.e. both go hand-in-hand, e.g. for

$\alpha_{\text{Motivation}}$, the allied construct chosen was ‘achievement satisfaction’ which may be described as a sense of gratification upon an achievement related to studies. The third query, rooted in SS layer, enquires about such a habit that shares a causal relationship with α attribute (Monat & Gannon (2023) regard ‘structure’ in systems thinking, as a “cause-and-effect manner”), and the degree of presence of this habit, indirectly gauges α ’s potency. For $\alpha_{\text{Supportive-A}}$, this habit was chosen to be ‘assisting class fellows’.

First person style is used for all queries instead of third person, as the latter steers a surveyee towards responding what he/she believes that others *should* do, rather than expressing what the surveyee himself/herself *would* do. The survey designing teacher needs to outline various ‘opposing forces’ for the α attribute(s), from the respondents’ point of view, as these forces can become costs for α . For instance, setbacks as well as lack of recognition can (lead towards demotivation and hence) be the opposing forces for motivation. Moreover, to lower (the “consistency motif” (Kock et al., 2021) of) common method bias, it is recommended to have at least one query which is reverse contextualized. The queries are now described further, with examples as in Table 1 – the complete queries for both attributes, along with translation/rephrasing for non-native English speakers, are given in appendix A.

Table 1. SR queries and responses

Q1	$[\alpha_{\text{Motivation}}]$ Do you believe that you pursue your engineering education as a whole, with suitable motivation (a passionate pursuit of learning) and this motivation does not fade away even when you have to work against challenges e.g. preparing exams of tough courses, obtaining low marks in a quiz or an exam, etc.? Please provide an overall answer, not specific to any single subject.	(a)I believe that I have adequate motivation for my studies. [T] (b)I believe I have mediocre (not very high, not very low) motivation. [M] (c)I think I may have very low motivation in engineering studies – and this is genuinely due to the circumstances around me. [B]
Q2	$[\alpha_{\text{Supportive-A}}]$ In case of your dealings with your class fellows, how would you rate yourself as being a self-centric person (i.e. a person whose focus is upon achieving personal goals, and he/she is not much concerned about needs/feelings of others)?	(a)I think I would consider myself as a self-centric person most of the times - every one should be focused towards his/her targets in life. [B] (b)I actually believe in being quite the opposite of a self-centric person, even if I have to struggle and work hard just for the sake of others. [T] (c)I may be self-centric at times, but on various other occasions, I try to look after the needs of others, even if it is difficult for me. [M]
Q3	$[\alpha_{\text{Supportive-A}}]$ Do you believe that you should have the habit of assisting class fellows, who need support in one way or the other, even if you have to go through a minor mental stress/tension in offering this help?	Please refer to appendix Table A1, Q3 for responses.

The challenges mentioned in the first query can elicit a perceived effort cost (preparing exam of tough courses) and a perceived emotional cost (obtaining low marks). Briefly describing ‘motivation’ helps to avoid any subjectivity in contemplation of the attribute. Requesting an overall answer (thus preventing students to respond with different courses/semesters in their minds) is another attempt to lower subjectivity. As regards responses, while (a) and (b) are straightforward, the third option, which is most prone to social desirability (SD) bias, illustrates the idea of morphing into social acceptability (which may draw support from idea of ‘neutralization’ mentioned by Kwak et al. (2021)), as its latter part allows a degree of legitimacy to selecting this option. Moreover, a surveyee’s truthfulness may also not be

compromised, as the DAC survey asks to select the most appropriate choice among all options, instead of that option which *exactly applies*.

The second query exemplifies reverse contextualization. The chosen MM layer construct, whose presence will actually negate the presence of a supportive attitude was ‘apathy’ or ‘self-centricity’. Also, this survey item exemplifies responses as an alternate location for costs i.e. responses can include costs, if they are not, or could not be conveyed in the query itself. Here an effort cost has been explicitly and then implicitly included in response options (b) and (c) respectively, option (a) i.e. B level response may be made cost less – however, it should be morphed for social acceptability, as is the case presented here. Lastly for the third query, it should be noted that the circumstances of a surveyee’s life might not have allowed the development of the intended habit, even though α is present.

This issue can be covered if the query asks ‘should you have such a habit’ instead of ‘do you have this habit’, or else the query can provide such conditions where the intended behavior is expected to manifest. For $\alpha_{\text{Supportive-A}}$, with ‘assisting class fellows’ as the chosen habit, the final query statement mentions ‘mental stress/tension’ as the perceived emotional cost.

3.2 The Vignette Approach Rooted in the PPCT Model

PPCT (process-person-context-time) is a model of Urie Bronfenbrenner’s bio-ecological theory of human development (Bronfenbrenner & Morris, 2006). In the field of learning, Tong & An (2024) review various studies which apply this theory in education. The same model has been regarded by Dastgeer & Kalam (2025) as a “potent” tool for an affective domain teacher and the article further mentions that the process part “will be the procedure/scheme used for assessment of affective attributes” and this process “needs to adopt an adequate methodology to prevent the shaping of the ABD from a contextual influence factor, as well as from an internal masking factor”. ABD stands for active behavioral disposition of a person, while the internal and (external) contextual influence factors (henceforth termed as β factors), refer to the intrinsic and extrinsic motives respectively (e.g. inner aspirations and outer societal pressure) that can force an individual to display such a behavior that wrongly suggests the presence of an AD attribute.

Dastgeer & Kalam (2025) mention that “[b]esides being observation based (where an ABD is being observed), the process may also include interviews or even surveys”. Hence we have the PPCT model as the foundation for one of the approaches (the vignette approach) of the DAC survey presented herein. The scenario created in the vignette statement generates the (imagined) context, various interactions mentioned in the vignette (plus the responses) become the process, surveyee is the person, and the queries which attempt to gauge α three times, touch upon the time aspect of the PPCT model. Unlike the SR approach, the three vignette queries are independent from each other and may be divided into two types.

3.2.1 Type 1 Queries – Case of one or more β factors

The scenarios with one or more β factors are codified as type 1A and type 1B queries respectively. Developing a vignette query for $\alpha_{\text{Supportive-A}}$ serves as an example; an initial version (Q.A) is given in Table 2. Prima facie, $\alpha_{\text{Supportive-A}}$ is being assessed by the vignette, however various β factors may surface as the survey designing teacher contemplates the vignette from students’ perspective. These can be a desire of good grades (β_{DGG} - the respondent wants to support Eta so that project assessment is not hampered), returning of favor (β_{RoF} - respondent desires to help out Eta, so that in a future instance, Eta may help him/her), earning-respect/showing-off (β_{ER} - respondent desires to earn respect of group members and supervisor by helping), liking for Eta’s work (β_{LFW} - respondent likes the FYDP portion assigned to Eta).

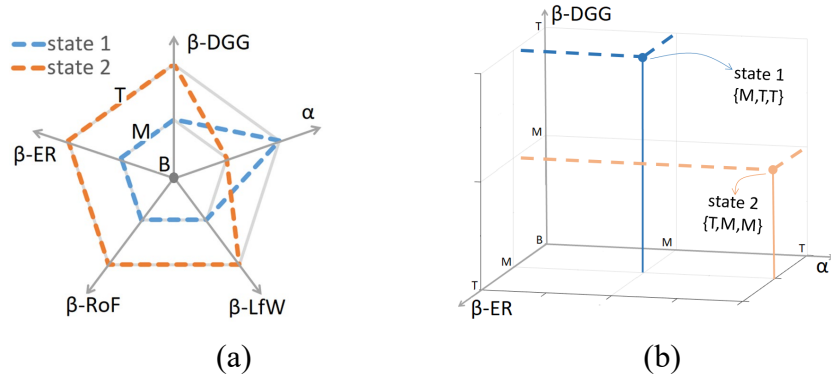


Figure 2. Multi-axes state spaces for original and modified vignette query *Q.A*

Figure 2 (a) illustrates the scenario of multiple β factors, as a state space depiction, with two sample states shown, both of which make a respondent selection option (a') i.e. the top response, although only one of the selections is genuinely based upon an actual $\alpha_{\text{Supportive-A}}$. To address this issue, firstly, the teacher can attempt to reduce the β factors via adjusting the vignette itself, e.g. following additions attempt to remove β_{LFW} and β_{RoF} respectively - '[a]ssume that when individual project tasks were divided among the group mates, you were able to select that task which you like the most, and the tasks assigned to your group mates were not within your area of interest' and '[y]ou actually dislike Eta's behavior (characterized by thanklessness, coldness, and lack of reciprocation of a favor)'. Hence, the query's state space is reduced to three dimensions as presented in Fig. 2 (b), with two sample states shown. Subsequently, for generating responses, the survey designing teacher should make a partial truth table (where β factors are co-varied compulsorily) as shown in Table 3.

Table 2. Vignette queries and responses

Q.A Initial version $\alpha_{\text{Supp.-A}}$	Assume the scenario that you have recently formed a three member group for your upcoming FYDP. Of your two group mates, there is one with whom you are friendly and collaborative, however, as regards the second group mate (whose name is 'Eta') you are quite uncomfortable and withdrawn. You actually dislike Eta's behavior and you did not want Eta to be part of your FYDP group in the first place, still this group was formed due to certain reasons. With the guidance of your project supervisor, all three of you divide the tasks - some tasks are individual while others are collective. In the second month of your 7th semester (around early October), your group has a meeting with the supervisor, and it is found out that your group's overall performance is satisfactory - all three of you are working adequately, completing the individual as well as collaborative tasks. Subsequently, towards the end of October, you have an FYDP presentation and all three of you need to work actively so as to gain good marks in this presentation based assessment. Two days before the project presentation, Eta gets stuck in one of the individual project tasks assigned to Eta, and needs help. Your third group member is not available due to being occupied in project relevant tasks, however, you have completed your relevant portion and can spare some time. Eta asks for	(a') I will positively respond to Eta's request and help out as much as I can. [T] (b) I may try to avoid helping Eta; anyway, if Eta insists I may go and provide some support. [M] (c') I will not help Eta, because this is Eta's individual task. [B]
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	your assistance. Which of the following best describes your response in this situation?	
Q.A final (res- ponses)	Final version is skipped here, refer to Q4 in Table A1	(a) I am of the view that I would provide assistance to Eta, just because Eta is a person in need and I am in a position where I can, and therefore should, provide assistance. [T] (b) I think I would go to help Eta, because of reasons such as: (i) helping out Eta means working towards my own FYDP, for which I desire to get good grades in the coming assessment (ii) assisting Eta can enhance my respect among my FYDP group mates and supervisor, (iii) other reason(s). [B] (c) I think I would go for Eta's help primarily because of reason mentioned in (a) and secondarily because of reason(s) mentioned in (b). [T] (d) I think I would go for Eta's help primarily because of reason(s) mentioned in (b) and secondarily because of reason mentioned in (a). [M] (e) I think I would go for Eta's help as I give equal weightage to reasons mentioned in (a) and (b). [T] (f) I may or may not go to help Eta - if I do go for Eta's help, it will be purely because of reason mentioned in (a). [M] (g) I may or may not go to help Eta - if I do go for Eta's help, it will be purely because of reason(s) mentioned in (b). [B]. (h) I may or may not go to help Eta - if I do go for Eta's help, it will be because of reason(s) mentioned in (a) as well as (b). [M] (i) I will not help Eta, because of the genuine reason that this is Eta's individual task. [B]
Q.B Motiv.	Assume that the 7th semester of your BSc Electrical Engineering degree program has just started, and for a certain core engineering course, a hard working and hard work demanding teacher has been assigned as the lecturer and course instructor. Assume that this is a new teacher, and your class has never studied from him before. However, word is around that this teacher is good in manners and is dedicated in the teaching process, wherein the teacher demands dedicated effort from the students as well. Some of your class fellows decide to make a request to the head of the department, via the class representative (CR), to change this teacher and instead assign this course to a different teacher who will be easy going in teaching and will not bother much about building concepts in the students. The CR asks each student of the class to give his/her opinion about this matter in a short time. Which of the following options, will best describe your personal opinion? Do not give your opinion based upon what your class fellows' opinion will be - give your own personal view point.	Refer to Q5 in Table A2

The responses should be developed so that each row of the table i.e. each state is covered by at least one response option, e.g. response (a) effectively covers state 1 {T,B,B}, however, it fails to be an adequate state attractor for states 2 {T,M,M} and 3 {T,T,T}, for which, options (c) and (e) are needed respectively; all response options are provided in Table 2. Moreover, to address any possible additional β factors, the response item (b) carries the looseness of ‘other reason(s)’ – this open-endedness may be used, as deemed necessary. Furthermore, the rationale for forcing co-variation of β factors is that, even if these factors are allowed to vary w.r.t. each other, the higher (or highest) level of the two (or more) β factors will decide the response selection, and these situations will be adequately attracted to the same nine responses as designed earlier. For instance, while state 1 {T,B,B} is attracted by response (a), the state {T,B,M} can easily be expected as being attracted by response items (a) or (c) – both are a correct evaluation for $\alpha_{\text{Supportive-A}}$. Furthermore, as regards cost, this query is expected to balance out the emotional cost of the third query (presented in previous subsection) for $\alpha_{\text{Supportive-A}}$.

Table 3. Partial Truth Table and Mapped Responses

State No.	$\alpha_{\text{Supportive-A}}$	β_{DGG}	β_{ER}	Mapped Responses
1	T	B	B	(a)
2	T	M	M	(c)
3	T	T	T	(e)
4	M	B	B	(f)
5	M	M	M	(h)
6	M	T	T	(d)
7	B	B	B	(i)
8	B	M	M	(g)
9	B	T	T	(b)

3.2.1 Type 0 Queries – No β factors

Type 0 attempts to nullify all potential β factors; a sample query (Q.B in Table 2) for $\alpha_{\text{Motivation}}$ illustrates the idea. Here, peer relationship can be one of the β factors and the sentence “[d]o not give your opinion based upon...” attempts to discourage a perceived peer relationship based response. “Assume that this is a new teacher, and your class has never studied from him before” serves to prevent the steering of a respondent’s thought process towards any teacher with whom the class has had a previous learning experience and the response may therefore be biased by that experience.

The segment “word is around that this teacher is good in manners” serves to prevent any negative thoughts, such as a presumed strictness/starkness of the teacher, from influencing the response. “[C]ore engineering course” serves to clarify that this is not an optional or low-significance course. Consequently, a typical response will (most likely) be based upon a genuine $\alpha_{\text{Motivation}}$. This item poses effort cost (for the needed hard work) and emotional cost (due to fear of poor grades), to a general surveyee. Lastly, for the administered survey, difficult words were translated/rephrased for non-native English speakers and queries of both approaches of both attributes were mixed up to minimize common methods bias.

4 Evaluating the Results of a DAC Implementation

Subsequent to conducting a DAC survey, comprising one or more α attributes, the teacher can evaluate the soundness of their implementation of the DAC scheme, at three levels.

4.1 Basic Operational Evaluation (Level 1)

The first level, applicable for small as well as large class sizes, performs DAC scheme specific evaluations, described subsequently. Two *genuine* measurements cannot posit α on the opposite extremes (i.e. Top and Bottom), hence all three responses (i.e. a triad) of one approach, should ideally be the same e.g. [T,T,T] or have a maximum difference of one category among them e.g. [T,M,T]. Responses [T,M,B] or [T,T,B] are discordant triads indicating a contamination (given an initial coherence of the survey items themselves, discussed later in this paragraph). To resolve a discordant triad e.g. a [B,M,T] response in SR approach, firstly the teacher needs to identify the contaminated response by consulting the corresponding triad in the vignette approach, say this is [T,T,M].

This triad must be concordant (otherwise, the surveyee response will be declared divergent altogether, even if ω scores match). Both triads are concatenated to form a single hexad ([B,M,T,T,T,M]), where the teacher looks for the individual discrepant response (evidently it is B, as the combined effect of the quintuple i.e. the remaining five responses, is placing the surveyee somewhere between Medium and Top levels). The discrepant response is discarded and the discordant triad, now becomes a concordant diad ([M,T]), subsequently, ω scores are calculated (diad ω score is scaled to three, thus all measurements conform to the same scale) and categorization and convergence criteria are the same as before.

Table 4. Results for pilot implementation (% values are out $N = 22$, self-assessment students)

		α Supportive-A	α Motivation
No. (&%) of concordant triads	SR approach	21 (95.5%)	18 (81.8%)
	Vignette approach	20 (90.9%)	17 (77.3%)
No. of SR & PPCT response pairs where both triads are concordant		19	15
No. (&%) of concordant AND convergent triad pairs		18 out of 19 (94.7%)	15 out of 15 (100%)
Category thresholds (& corresponding No. of convergent student cases)	Low	1 (0)	1 (0)
	M. Low	1.6 (4)	1.4 (1)
	Medium	2.1 (10)	1.8 (5)
	M. High	2.5 (5)	2.2 (5)
	High	2.75 (2)	2.6 (7)
Convergence status with No. (&%) of cases	M0 convergence	5 (22.7%)	10 (45.5%)
	M1 convergence	9 (40.9%)	4 (18.2%)
	M $\pm$ 1 convergence	4 (18.2%)	1 (4.5%)
Convergent cases with 1 less item (i.e. 5 items)		3 (13.6%)	3 (13.6%)
Total convergent cases		21 (95.5%)	18 (81.8%)
Divergent cases		1 (4.5%)	4 (18.2%)

Moreover, an initial indication of coherence of the survey (consistent with an expected nomological association (Hagger et al., 2017)) can be inferred if a clear majority of the respondents, in both approaches, yield concordant triads in their SR and vignette approaches, and subsequently, nearly all respondents with concordant triads (i.e. intra-approach coherence) show inter-approach convergence. The latter requirement is kept stricter because in the absence of marked intra-approach discordance, operational convergence between the two approaches is the central theme of the DAC framework. The results for the conducted pilot study, gauging attributes $\alpha_{\text{Supportive-A}}$ and $\alpha_{\text{Motivation}}$, as presented in Table 4 show that both attributes fulfilled the preliminary coherence criteria. Moreover, the current manuscript proposes 70% and 90% values as provisional thresholds for the intra-approach concordance and inter-approach convergence for calibration in future studies.

These provisional thresholds (neither preregistered nor empirically validated), termed λ values (refer to appendix B for related 95% Wilson confidence intervals) need further research effort for their deeper theoretical grounding. Subsequent to preliminary coherence check, the divergent cases, may reflect such biases, un-catered β factors, mismatched costs or a lack of student engagement that could not be cleared out via discord resolving. Thus, although divergent cases can be categorized based on their ζ score; still, for the final evaluation of a set of students, the teacher will exclude the divergent cases (from the convergent categorization only, not from the dataset) and the picture painted only by the convergent surveyees (which should be a majority portion of the class if appropriate λ thresholds are satisfied and an adequate number of discordant triads is resolved, as discussed earlier) will be considered as the cohort situation.

Categorization can be performed at this point, and a straightforward way is to assume that the BMT levels posited in various queries by the teacher, are actually *the* Low, Medium and High levels for that α attribute. Thus a final score $\zeta = 2$, places the respondent in Medium category, and all categories are allocated equal space in the number line 1 – 3, as in Fig. 1. This strategy was used for $\alpha_{\text{Motivation}}$ and thresholds as well as students falling in each category are shown in Table 4. A second way is to assume that, for a particular α , the average standing (i.e. mean value of ζ) for all the surveyees, should be the basis for deciding Medium category. This method was used for $\alpha_{\text{Supportive-A}}$ where average ζ was equal to 2.3, hence Medium category was decided to be: $2.1 \leq \text{Medium} < 2.5$. The remaining categories are allocated the residual space on number line. Table 4 gives detailed results as well as category thresholds.

Furthermore, for clarification a worked example of the categorization procedure is provided here. For $\alpha_{\text{Supportive-A}}$, the response triads of respondent#1 were [T,M,M] and [T,T,T] for SR and vignette approaches respectively. Both triads are concordant and translate to coded groups of [3,2,2] and [3,3,3] giving ω_{SR} and ω_{Vignette} equal to 2.33 and 3.00; as their difference $\leq \text{MMC}$ (which is 0.67) hence cross-approach convergence is achieved. Subsequently, ζ is calculated to be 2.665 which lies in M. High category range (see Table 4 for category thresholds). As regards status of convergence, ω_{SR} and ω_{Vignette} individually tended to place the respondent in Medium and High categories, since the finalized category is ± 1 category apart from these two, hence convergence status is $M \pm 1$ convergence.

Moreover, a category cut-point sensitivity analysis was also performed for both affective attributes, where all interior category thresholds were shifted simultaneously (end points of 1 and 3 remained same) and the results are presented in Table 5. No change of more than one category step was observed in either of the attributes and $\alpha_{\text{Motivation}}$ showed more stable classification as compared to $\alpha_{\text{Supportive-A}}$ and this is consistent with a better evaluation of $\alpha_{\text{Motivation}}$ as discussed in basic psychometric diagnostics subsequently.

Table 5. Sensitivity of categorization to category threshold perturbation ($N=22$)

Attribute	Cut-point perturbation	Total No. of classification changes	No. of classification changes larger than one category step	Cohen's Kappa (similarity between original and perturbed classification)
$\alpha_{\text{Supportive-A}}$	+0.1	7	None	0.767
	-0.1	7	None	0.820
$\alpha_{\text{Motivation}}$	+0.1	2	None	0.954
	-0.1	4	None	0.900

4.2 Basic Psychometric Diagnostics (Level 2)

The second level of evaluating an implementation of the DAC scheme is to psychometrically gauge (rank order) coherence between the two approaches as well as item-total cohesion. However, it must be emphasized that this evaluation level only provides descriptive diagnostics, relevant to the particular classroom and localized CQI; they do not provide evidence of the generalizability of a developed survey. This level is again recommended to be performed for small as well as large class sizes.

Firstly, for the cross-approach association, MTMM style (convergent/discriminant) analysis may be performed, however, for a teacher gauging a single attribute of their class, via only two methods (approaches), a full scale MTMM matrix will not be constructed, rather analysis will be scaled down to a monotrait cross-approach analysis, yielding a single correlation of both approaches unable to check discriminant validity. Again, for small class size, the results should be especially interpreted as descriptive diagnostics. For the conducted pilot study, Spearman rank correlations (r_s) were used for this analysis and were found to be 0.397 and 0.560 for $\alpha_{\text{Supportive-A}}$ and $\alpha_{\text{Motivation}}$ with p values 0.067 and 0.007 respectively. The p values again need careful consideration, a teacher may achieve statistically significant (i.e. <0.05) p value, as in case of $\alpha_{\text{Motivation}}$, which combined with $r_s = 0.560$ shows a moderately strong association between their designed SR and vignette queries.

Contrarily p values may remain unable to fulfil the $p < 0.05$ criterion, as in case of $\alpha_{\text{Supportive-A}}$, however, the related $r_s = 0.397$ still indicates a positive association between the two approaches, though evidence is insufficient to reject null hypothesis. While both cases can be used for local classroom CQI, neither provides sufficient evidence for the generalizability of the developed set of queries. Thus, on the whole, this first part of level 2 evaluation, can psychometrically indicate if surveyees responding high in one approach tend to respond relatively high in the associated second approach, and thus a teacher has their first psychometric indication of coherence in their implementation i.e. results are consistent with the presence of a common trait-related component in the two approaches. Moreover, as the conducted pilot study gauged two affective traits, hence an MTMM style dual-trait cross-approach matrix could also be developed and is provided in appendix B.

The second part (of this level 2 evaluation) should look deeper towards an item level internal consistency diagnostic, observing the cohesion of individual items in the complete DAC implementation comprising six queries which intend to gauge the same latent affective attribute, and for which positive cross-approach r_s have been achieved in the previous part. A teacher can use corrected item-total Spearman correlations at this stage, for the conducted pilot study, these correlations are provided in Table 6, indicating that $\alpha_{\text{Motivation}}$ shows generally stronger item-rest correlations as compared to $\alpha_{\text{Supportive-A}}$, and this finding is consistent with cross-approach correlations for both attributes. While Q3 of $\alpha_{\text{Supportive-A}}$ is at the borderline of the commonly used descriptive benchmark of 0.30, Q2 and Q4 show

potential design weakness, and so is the case of Q4 for $\alpha_{\text{Motivation}}$. It should be noted that such item-level design weakness can arise where a teacher implements the DAC scheme, for their local classroom assessment and CQI, without any extensive expert review of the implemented scheme or a high level psychometrical calibration. The teacher can now perform item-omission sensitivity analysis intended to judge if the potentially weak queries are disproportionately affecting the final student categorization. To this end, a query with weak item-rest correlation will altogether be temporarily removed and categorization performed without it. The convergence criterion will remain the same; for discord resolving, a tetrad will be used instead of a quintuple. Subsequently, Cohen's Kappa (quadratically weighted) may be computed to investigate the similarity between the original scheme (of six queries) and the new scheme (with five queries), for all surveyees.

For the implementation in the pilot study, κ value of 0.85 and 0.80 were found post individual discarding of Q2 and Q4 of $\alpha_{\text{Supportive-A}}$, respectively. In fact, categorization was performed post discarding both Q2 and Q4 (leaving dyads in both approaches instead of triads), and this yielded a κ value of 0.80. Also, a κ of 0.88 was computed, post discarding Q4 of $\alpha_{\text{Motivation}}$. Achievement of high κ values informs the teacher about the stability in categorization post discarding potentially weak queries (i.e. robustness to weakness in implementation), though this stability cannot be linked to validity or reliability of the developed survey. The teacher may then use the original (pre- item omission) student categorization for local CQI, however, if the κ values are small indicating significant categorization changes, careful re-assessment and cautious review of the implementation may be needed.

Table 6. Corrected item-total Spearman correlations

Attribute	Query	Corrected item-total r_s
$\alpha_{\text{Supportive-A}}$	Q1	0.381
	Q2	0.000
	Q3	0.291
	Q4	0.157
	Q5	0.477
	Q6	0.358
$\alpha_{\text{Motivation}}$	Q1	0.429
	Q2	0.376
	Q3	0.597
	Q4	-0.215
	Q5	0.323
	Q6	0.516

Another sensitivity analysis (presented here as an exploratory procedure) may be to only omit those responses of a potentially weak query, which are the most distant on a Bland-Altman plot of the query responses and the ζ score. These maximal-disagreement responses may be operationally treated as outliers, for the purpose of sensitivity analysis. Once again, as each item of a triad is supposed to be gauging the same latent affective attribute, hence an omitted response is replaced, solely for this sensitivity procedure, by the mean of the other two responses of the same triad of the same respondent. The purpose will be to compare the final

categorization, now performed with the omission of the maximal-disagreement responses and the original categorization (which included these outlier items); and if the categorization largely remains the same, this again supports the preliminary inference that the weakness in designing of a single query does not substantially affect the stability of the resultant categorization of the DAC scheme. Fig. 3 shows Bland-Altman plot (with horizontal dashed line showing the mean difference) for $\alpha_{\text{Supportive-A}}$. It is emphasized that Bland-Altman procedure is used here as a diagnostic as well as visualization tool, only for specific queries; these plots are not being utilized for deducing statistical inferences related to the agreement between two continuous measurement methods.

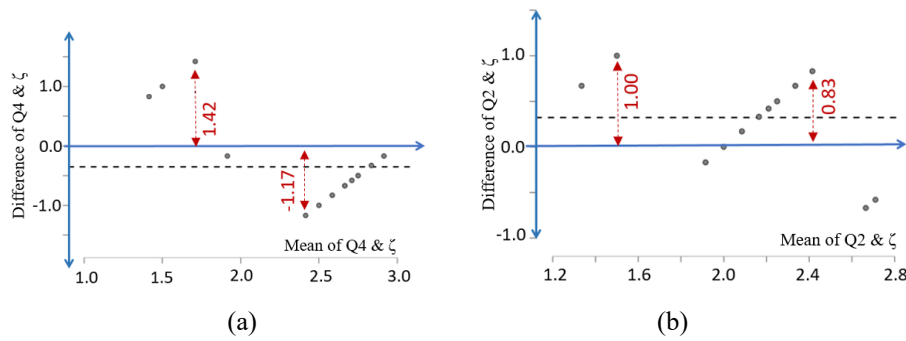


Figure 3. Bland-Altman Plots for $\alpha_{\text{Supportive-A}}$

For Q4, two extreme points were designated as maximal-disagreement points and were detected to be R#6 (respondent#6) with a difference of 1.42 and R#11 with a difference of – 1.17, having responses [1,2,3] and [3,2,2] for the [Q4,Q5,Q6] vignette triad, respectively. Subsequent procedure led to no change in final categorization of these two respondents. Afterwards, two maximal-disagreement points were detected for Q2, which corresponded to R#4, R#15 and R#21. The prior procedure was repeated, which led to one change in categorization (R#4 moved from M. Low to Medium). Now for judging agreement between original categorization, and the categorization post handling of maximal disagreement points, κ value was found, equal to 0.97 which is very high because of only one step change for only one respondent. Similarly, handling the maximal-disagreement responses of Q4 of $\alpha_{\text{Motivation}}$ led to a κ of 0.90. In summary, this sensitivity analysis indicates that overall, categorization is substantially the same, as that which existed prior to handling the maximal-disagreement points.

In other words, for the present pilot, a small set of highly disagreeing responses did not disproportionately affect the overall categorization process of the DAC framework. Finally, it may be recommended that any query which needs more than a certain percentage of data points to be treated as operational outliers and replaced, should itself be declared unsuitable and be modified for the next iteration of the survey. Bland-Altman plots can assist in this modification, as the mean difference line informs if a query is overall gauging an α lower than the ζ score (e.g. Q4 – ζ plot) or vice versa. Subsequently, its cost balancing may be revisited and query be modified.

Lastly, it should be noted at this stage that various other internal consistency coefficients may not provide sufficiently stable results for a DAC scheme implementation with a small class size. For instance, Cronbach's alpha is not well-suited for a three category ordinal response data. Ordinal alpha's underlying polychoric correlations would again be inappropriate for a small class size ($N=22$) and resulting sparse item-pair contingency table. Similarly, McDonald's omega needs stable estimates of factor loadings and residual variances, which is again unfit for a small three category dataset. Hence, item-rest Spearman coefficients are presented as descriptive internal consistency diagnostics at the item level. Moreover, for

implementation of DAC scheme, Microsoft Excel can be used to automatically calculate the ω and ζ scores, identify and resolve certain cases of discordant triads, categorize the students into the five categories (with adjustable thresholds), highlight the divergent cases and to allow the altogether discarding of a query (in each approach). This template Excel file, also having the data for $\alpha_{\text{Supportive-A}}$ and $\alpha_{\text{Motivation}}$ surveys (as samples), is available online (Dastgeer, 2025).

4.3 Extended Psychometric Evaluation (Level 3)

The third level of evaluating a DAC implementation can use detailed psychometric evaluation in order to provide support for validity and reliability of a developed set of queries. This level, however, is not applicable to small class sizes; it may be needed when the goal is to develop a reusable and widely applicable survey instrument, beyond the scope of a localized classroom. At this stage confirmatory factor analysis can be used (provided a suitable number of respondents exist so that a stable factor structure can be obtained) as well as other measures of invariance and reliability. As the pilot study presented in this paper was based on a relatively small cohort ($N=22$), hence the third level of evaluation is inapplicable, but an exploratory factor analysis is nevertheless presented as a descriptive study. The factor analysis used the combined data comprising query responses as well as ω and ζ score (including the divergent cases), separately for both α attributes. Strong (>0.75) factor loadings were observed for all ω and ζ scores which is to be expected in current data structure where ω and ζ values are derived from query scores, hence the loadings do not provide independent evidence of validity.

Furthermore, as regards individual queries, the loadings were larger than the common benchmark of 0.4 for all queries except Q2 & Q4 of $\alpha_{\text{Supportive-A}}$ and Q4 of $\alpha_{\text{Motivation}}$; these findings are consistent with the item-rest correlations presented earlier. Formal level 3 evaluation should preferably use an adequately powered set and raw item scores to test the proposed latent factor and then observe association between the latent factor and ω and ζ scores. For a future dedicated level 3 evaluation, the required sample size can be determined via an a priori Monte Carlo simulation with the proposed factor structure and other related parameters. Furthermore, *measurement invariance* (Putnick & Bornstein, 2016) is another venue of research related to the DAC framework; for the current pilot study, as it was based on a single administration to a single cohort so different invariances (metric, scalar) were not determined.

5 Concluding Discussion

The current article introduced the broad framework of a dual approach survey, for gauging the affective attribute standing of a student cohort, by categorizing individuals into one of five categories via the convergence of both approaches at or around the final category. The dual approaches of direct self-reporting and scenario-based questioning are rooted in iceberg model of systems thinking and PPCT model of Bronfenbrenner's bioecological systems theory, and cost balancing is incorporated in query designing to posit similar psychological cost in both approaches.

Various intricacies related to cross-approach convergence, intra-approach concordance, margin of convergence etc., were presented in the manuscript, which on the whole attempts to make a methodological contribution to the body of knowledge. On the empirical side, a small scale pilot implementation of the DAC survey was conducted which served to provide a preliminary feasibility indication for the DAC scheme. The pilot study was able to categorize a majority of students in the full cohort of 28 students (22 self-assessment, 4 peer-assessment

plus 2 inclusive survey students), via convergence of two approaches. For $\alpha_{\text{Supportive-A}}$ and $\alpha_{\text{Motivation}}$ attributes, 21/28 (75%) and 18/28 (64.29%) students were categorized with cross-approach convergence.

Furthermore, while it may still appear that not having all the students to portray the whole class is an imperfect evaluation for the class, it may contrarily be argued that, a conventional single approach assessment, which includes the responses of such surveyees which a DAC scheme attempts to exclude (due to e.g. biased responding, lack of engagement etc.) could lead to an even more imperfect evaluation of the class. Lastly, it must be mentioned that, as this paper endeavoured to encompass various breadth-based aspects of this new framework, it remained unable to cover the depth side of exploration and this area needs to be studied in detail to provide definitive verdict on the stability and feasibility of the presented dual approach convergent scheme.

As regards future development studies, cognitive interviews can be conducted to comprehend how the respondents interpreted the queries, vignettes and responses, thus providing evidence for response-process validity. Also, the current pilot implementation of the DAC framework was tested with a single group of students (power limitation to N=22 self assessment students), in a single institute and program, who were asked to voluntarily participate in this survey, while they were on summer vacation (which may have affected student engagement) and hence survey (and prior to that, their consent) was taken online. No a priori power analysis was used to determine the sample size of N=22. Hence the results of this pilot implementation are not sufficient evidence of generalizability of the results of this DAC survey across other institutes, programs or student groups. Adequately powered multi-cohort testing can be performed for implementations of DAC framework, examining measurement invariance. The effectiveness of the peer-assessment instrument, which was intended here to encourage student engagement and honesty, was not gauged in the current pilot study and this could also be a subject of future research which may compare student categorization results with and without the use of peer-assessment.

6 Appendices

6.1 Appendix A – SR and Vignette Items for Pilot Study

The full text of queries are provided here in tabular form, the curly brackets contain rephrasing text or translation which was performed for ease of non-native English speakers. Furthermore, anticipated costs and the BMT levels are mentioned in square brackets. The first three queries of each table present the SR items and the next three present vignette items, although for actual conducted survey, the items were mixed up.

Table A1. Queries and responses for $\alpha_{\text{Supportive-A}}$ attribute

	Query Text	Responses
<i>Q1</i>	Do you believe that you possess a supportive attitude towards class fellows, so that you would try to assist them where needed, even if the scenario is challenging and it is genuinely difficult for you to lend a hand {i.e. provide help}?	(a) In my case, I simply do not believe in having this attitude. Everyone should struggle himself/herself in order to achieve his/her goals. [B] (b) I would say that I do desire to help my class fellows, however, how much of a support I can offer...this depends upon the availability of my time and convenience of opportunity. [M] (c) I think yes, I do possess this attitude - I would try my best to help my class fellows even if I am taking a chance with my own

	Query Text	Responses
		benefit, whenever my help is truly needed. [T]
Q2	In case of your dealings with your class fellows, how would you rate yourself as being a self-centric person (i.e. a person whose focus is upon achieving personal goals, and he/she is not much concerned about needs/feelings of others)?	(a) I think I would consider myself as a self-centric person most of the times - every one should be focused {i.e. having a focus} towards his/her targets in life. [B] (b) I actually believe in being quite the opposite of a self-centric person, even if I have to struggle and work hard just for the sake of others. [T] (c) I may be self-centric at times, but on various other occasions {i.e. events}, I try to look after the needs of others, even if it is difficult for me. [M]
Q3	Do you believe that you should have the habit of assisting class fellows, who need support in one way or the other, even if you have to go through a minor mental stress/tension in offering this help?	(a) Yes, I would like to help some one who needs assistance, even if I have to face a bit of stress and un-easiness in offering the help. [T] (b) I think I may help some one requesting assistance, but if I feel mentally un-easy, I will only offer limited help. [M] (c) Un-necessary tension/stress is inappropriate {i.e. not suitable} for a person's mental health - I will not like to offer help in a scenario which brings tension. [B]
Q4	Assume the scenario that your three member group for your FYDP has been dissolved {i.e. khatam ho gya} due to certain issues, and you have to make a new group for the project in September. Of your two group mates, there is one with whom you are friendly and collaborative, however, as regards the second group mate (whose name is 'Eta') you are a bit uncomfortable and withdrawn. You do not like Eta's behavior and you did not want Eta to be part of your FYDP group in the first place, still this group was formed due to certain reasons. With the guidance of your project supervisor, all three of you divide the tasks - some tasks are individual while others are collective. In the second month of your 7th semester (around early October), your group has a meeting with the supervisor, and it is found out that your group's overall performance is satisfactory - all three of you are working adequately {i.e. suitably}, completing the individual as well as collaborative tasks. Subsequently, towards the end of October, you have an FYDP presentation and all three of you need to work actively so as to gain good marks in this presentation based assessment. Two days before the project presentation, Eta gets stuck in one of the individual project tasks assigned to Eta, and needs help. Your third group member is not available due to being occupied in project relevant tasks, however, you have completed your relevant portion and can spare {i.e. take out} some time. Eta asks for your assistance. Which of the following best describes your response in this situation? [Emotional cost – to balance SR item Q3]	(a). I am of the view that I would provide assistance to Eta, just because Eta is a person in need and I am in a position where I can, and therefore should, provide assistance. [T] (b). I think I would go to help Eta, because of reasons such as: (i) helping out Eta means working towards my own FYDP, for which I desire to get good grades in the coming assessment (ii) assisting Eta can enhance my respect among my FYDP group mates and supervisor, (iii) other reason(s). [B] (c). I think I would go for Eta's help primarily because of reason mentioned in (a) and secondarily because of reason(s) mentioned in (b). [T] (d). I think I would go for Eta's help primarily because of reason(s) mentioned in (b) and secondarily because of reason mentioned in (a). [M] (e). I think I would go for Eta's help as I give equal weightage to reasons mentioned in (a) and (b). [T] (f). I may or may not go to help Eta - if I do go for Eta's help, it will be purely because of reason mentioned in (a). [M] (g). I may or may not go to help Eta - if I do go for Eta's help, it will be purely because of reason(s) mentioned in (b). [B]. (h). I may or may not go to help Eta - if I do go for Eta's help, it will be because of reason(s) mentioned in (a) as well as (b). [M] (i) I will not help Eta, because of the genuine reason that this is Eta's individual task. [B]

	Query Text	Responses
Q5	Consider the scenario that for a certain core course in the 7th or 8th semester of your BSc Electrical Engineering program, a teacher announces a surprise quiz, which will be numerical question(s) based, during a lecture. This quiz carries 10 marks and will be held just 30 minutes after completion of the teacher's lecture - the course contents for this quiz comprise topics 'A', 'B' and 'C'. All the students start to prepare for the quiz immediately after the lecture, as they only have half an hour for this preparation. You have a basic understanding of topics 'A' and 'C', however, you did not take the lecture of topic 'B', hence you feel a bit tense because if the numerical question of the quiz is based on topic 'B', you may not be able to solve it. So, you decide to dedicate a large part of the 30 minutes to this topic. Most of your class fellows are sitting in the class room, which becomes a noisy place, hence you decide to move from that place, and you find a bench in the corridor, with none of your class fellows around. As you start to prepare for this quiz, a class fellow of yours (named 'Lambda') approaches you and asks for your guidance in preparing topic 'A' for the quiz, because Lambda did not take the lectures of topic 'A', and is quite blank in this topic. You request Lambda to ask some one else, because you are already deficient in time, however, Lambda informs you that no body else accepted Lambda's request, and Lambda has therefore come to you. Which of the following will best describe your response to Lambda? [Emotional and Opportunity costs – to balance SR item Q1]	(a) The present scenario would compel me to politely refuse. [B] (b) I think I may give a bit of guidance to Lambda, however, naturally my preference would be my own preparation. [M] (c) I think my approach would be to guide Lambda adequately plus speed up my own study - I would do so even if I am taking a bit of risk with my own preparation. [T]
Q6	Assume that you are a boarding {i.e. hostelite} student, residing in one of the halls of the campus during your study here. Further, assume that you have a room which you share with two other students, both of them are students of Chemical Engineering. You have a nice working relationship with both and you get along well. One of these room-mates, named 'Omega' is a Table tennis enthusiast and is preparing these days for an inter-university Table tennis competition. Your hostel has a Table tennis setup, but very few students are interested in this game. Omega generally does not find some one to play Table tennis with. Consequently, Omega asks you to be the opposite player so that Omega can at least practice the game regularly. Omega has taught you the game, and you can play at a beginner level, however, you are not interested in the game at all and you find no fun/enjoyment in it. As Omega asks you time and again for practicing Table tennis, which of the following best describes your response to Omega? [Effort cost – to balance SR item Q2]	(a) I think I will not be able to play with Omega at all - how can I be part of a sports in which I have absolutely no interest? [B] (b) I think I will try my best to support Omega by playing Table tennis as per Omega's requests, and I would do so only because I consider it a moral obligation {i.e. ethical responsibility} to help some one who asks for assistance, when I can. [T] (c) I think I will try my best to support Omega by playing Table tennis as per Omega's requests, and I would do so only because, as I stand by {i.e. support} Omega in one place, I expect Omega to stand by me in another. [B] (d) I will provide as much practice opportunities to Omega as I can, due to reasons mentioned in both (b) and (c). [T] (e) I think I will provide as much opportunities to Omega as I can, primarily due to reason mentioned in (c) - and a secondary, less importance reason for this help, would be that which is mentioned in point (b). [M] (f) I think I may go to play with Omega occasionally {i.e. some times}, when I can spare some time - and this would be due to my desire of supporting a person who is requesting help. [M]

	Query Text	Responses
		(g) I think I may go to play with Omega occasionally, when I can spare some time - and this would be because I expect a return of favor from Omega, when I am in need. [B] (h) I think I may go to play with Omega occasionally, when I can spare some time - due to reasons mentioned in both points (f) and (g). [M]

Table A2. Queries and responses for $\alpha_{Motivation}$ attribute

	Query Text	Responses
Q1	Do you believe that you pursue your engineering education as a whole, with suitable motivation (a passionate pursuit of learning) { i.e. aik munaasib jazbai or shoq kai saath} and this motivation does not fade away even when you have to work against challenges e.g. preparing exams of tough courses, obtaining low marks in a quiz or an exam, etc.? Please provide an overall answer, not specific to any single subject.	(a) I believe that I have adequate {i.e. suitable} motivation for my studies. [T] (b) I believe I have mediocre (not very high, not very low) motivation. [M] (c) I think I may have very low motivation in engineering studies – and this is genuinely due to the circumstances {i.e. soorat-e-haalaat} around me. [B]
Q2	In general, do you find such pleasure and satisfaction upon learning new topics of engineering in your degree program, so that you are willing to exert suitable efforts in the learning process, in order to gain this pleasure and satisfaction? Give an overall answer, not specific to any single subject/domain.	(a) Simply put, I don't think there is any significant pleasure in learning of engineering topics - I just do my study, because I have to do it. [B] (b) I think I do find some pleasure in learning engineering topics - but it depends on various things. [M] (c) On the whole, I find adequate {i.e. suitable} pleasure and satisfaction in learning engineering topics, and I am willing to put suitable effort, unless a serious issue prevents me from making the effort. [T]
Q3	Do you think that you would eagerly {i.e. enthusiastically – shoq sai} accept optional tasks assigned in different courses to increase your knowledge about course topics? Example tasks may be having to read a web article in your free time, or having to watch a short video about a topic, etc. Please provide an overall answer, not specific to any single subject.	(a) I think, compulsory {i.e. must do} tasks are enough for engineering education - there is no need to further over-burden yourself with optional tasks. [B] (b) I am of the view that I would have a mediocre {i.e. medium} yearning {i.e. desire} to accept such optional tasks. [M] (c) I think I would like to accept such tasks eagerly and I would actively pursue their completion, when I have a chance. [T]
Q4	Consider the scenario that you are in the 7th semester of your degree program and one month has passed since the beginning of the semester (i.e. September has passed and October has arrived). You selected a final year design project (FYDP 'A') based upon deep interest and motivation, and your FYDP team members are also supportive. Some class fellows did suggest that you are selecting a difficult FYDP, but you rejected their opinion and moved on with your choice. In early October, you and your team mates have a meeting with your project supervisor - during this meeting you	(a) I think course work and labs are quite enough to gain engineering knowledge and skills - there is no particular need to make one's life difficult by selecting a complicated FYDP - so I would simply change my choice and select FYDP 'B'. [B] (b) FYDP 'A' is technically a better choice from engineering point of view, hence I may take 2-3 days to re-assess it and if possible, scale it down, so that it may be do-able with a medium effort and work input. If this is not

	Query Text	Responses
	present your initial working to the supervisor. However, the supervisor points out some deficient aspects in your approach and in this meeting, your group finally comes to the conclusion that the project is indeed more difficult than previously expected. The supervisor gives your group two options for future: i. Continue with the FYDP 'A' - in this case, you will definitely learn more; at the same time your group will have to make sincere endeavors {i.e. efforts}. The project will be successful if at least one of you puts decent effort towards project completion. ii. Give up FYDP 'A' and select FYDP 'B' which is relatively simple and less demanding. Assume that your selection of FYDP 'A' or 'B', does not affect your immediate job/higher-studies opportunity, after completing your degree. Which of the following best describes the course of action which you will follow? [Effort cost - to balance SR item Q2]	possible, then I would go with FYDP 'B'. [M] (c) It is a disgrace {i.e. Bai-izzati} to revert your own FYDP selection, therefore may be I will take 2-3 days to re-assess FYDP 'A' and if possible, scale it down, so that it may be do-able with a medium effort and work. If this is not possible, then I would go with FYDP 'B'. [B] (d) Reasons given in both (b) and (c) (i.e. FYDP 'A' is technically better to do, plus it is a shame to revert your own selection) are valid points to re-assess the project, looking for a possible option of scaling down - if this option does not exist, I would go with FYDP 'B'. [M] (e) I think I will continue with the FYDP 'A' because it is a shame and disrepute {i.e. Bai-izzati} to revert one's own selection/choice. [B] (f) I will surely continue with FYDP 'A' because it is technically a better project than FYDP 'B', and I believe that I can put-up suitable effort to complete the project. [T] (g) Both (e) and (f). [T]
Q5	Assume that the 7th semester of your BSc Electrical Engineering degree program has just started, and for a certain core engineering course, a hard working and hard work demanding teacher has been assigned as the lecturer and course instructor. Assume that this is a new teacher, and your class has never studied from him before. However, word is around {i.e. suna ja raha hai} that this teacher is good in manners and is dedicated in the teaching process, wherein the teacher demands dedicated effort from the students as well. Some of your class fellows decide to make a request to the head of the department, via the class representative (CR), to change this teacher and instead assign this course to a different teacher who will be easy going in teaching and will not bother much about building concepts in the students. The CR asks each student of the class to give his/her opinion about this matter in a short time. Which of the following options, will best describe your personal opinion? Do not give your opinion based upon what your class fellows' opinion will be - give your own personal view point. [Effort and emotional costs - to balance SR item Q1]	(a) I think I would use some common sense and suggest that the course should be taught by the hard working teacher, however, a settlement should be made with the teacher that the teacher will not go too deep in theory and concepts - rather the teacher will teach in a mediocre {i.e. medium} way. [M] (b) If the course can be covered easily, then why take the difficult way... so I will vote for the easy going teacher. [B] (c) I would simply vote in favor of having the hard working and dedicated teacher. [T]
Q6	Assume that you know a certain student 'Alpha' who is in the final year of BSc in Mechatronics Engineering or BSc in Chemical Engineering, at your campus. Alpha has been an avid {i.e. active & enthusiastic} learner throughout the degree program. Besides actively taking the class lectures and getting good grades in exams, Alpha has a habit of reading a variety of supplementary {i.e. additional} technical and scientific articles, books and magazines. Alpha is of the view that this approach keeps a person updated about recent trends in	(a) I think I would deeply revere {i.e. feel deep respect/admiration for} Alpha because of Alpha's genuinely earned respect from class fellows/teachers, and I should sincerely try to be like Alpha because of this regard and respect that Alpha receives. [Socially Desirable - B] (b) I think I should primarily try to be like Alpha because of the respect mentioned in (a) - furthermore, Alpha is a good learner too, so

	Query Text	Responses
	engineering and sciences. Alpha enjoys the learning process and some times Alpha's gossip {i.e. gup-shup} with class mates is also focused around diverse topics of technical and engineering background. Subsequent to reading this vignette {i.e. short story/description}, what will be your opinion about Alpha, in regards to Alpha's learning approach? Note: Only provide your answer based upon Alpha's learning approach and behavior. [Effort cost – to balance SR item Q3]	this would be my secondary reason for trying to be like Alpha. [Socially Desirable - M] (c) I think I would deeply admire Alpha, and I should try to be like Alpha, simply because Alpha is a true learner, categorically {i.e. clearly} interested in gaining engineering knowledge and expertise. [T] (d) Both (a) and (c). [T] (e) I think I should try to adopt some of Alpha's learning habits/approaches because these can help me in remaining updated in regards to my engineering knowledge. [M] (f) I would say that Alpha receives a decent respect from teachers and students - so I should try to adopt some of Alpha's learning habits. [B] (g) Both (e) and (f). [M] (h) I think completing your BS program is an educational milestone - as long as I am able to suitably acquire this degree, and then move on in life, I am fine with this - there is no need to adopt Alpha's learning approach. [B]

6.2 Appendix B – Methodological Transparency

Various *operational thresholds* were developed using the exploratory pilot study, and were not preregistered. Such thresholds are to be treated as post hoc choices, needing future detailed psychometric studies for theoretically grounded values.

Moreover, 95% Wilson score confidence intervals were computed for the pilot survey results, as they indicate the presence of uncertainty linked to the small size of the pilot study. For $\alpha_{\text{Supportive-A}}$ these intervals were 78.2% – 99.2% for SR concordance, 72.2% – 97.5% for vignette concordance and 75.4% – 99.1% for cross approach convergence (computed out of concordant triad pairs only, as in Table 4). For $\alpha_{\text{Motivation}}$ these intervals were 61.5% – 92.7%, 56.6% – 89.9% and 79.6% – 100% respectively. Relating these confidence intervals with λ values, we see that (despite all point values exceeding corresponding proposed λ thresholds) the lower confidence bounds for several estimates fall below the corresponding λ values, indicating that the sample population is not sufficiently large to provide a general attainment of these thresholds. Hence, as mentioned earlier, the provided λ values should be used by future studies, as provisional figures needing calibration.

Table A3 presents Spearman rank coefficients for an MTMM-pattern analysis, results show appreciably larger same-trait cross-approach association as compared to cross-trait associations, supporting the preliminary indication that SR and vignette approaches were able to capture a common component related to the trait being gauged.

Table A3. Spearman rank coefficients for an MTMM-pattern analysis

		$\alpha_{\text{Supportive-A}}$		$\alpha_{\text{Motivation}}$	
		SR approach	Vignette approach	SR approach	Vignette approach
$\alpha_{\text{Supportive-A}}$	SR approach	1.000	0.397	-0.121	0.068
	Vignette approach	0.397	1.000	0.019	0.088
$\alpha_{\text{Motivation}}$	SR approach	-0.121	0.019	1.000	0.560

		$\alpha_{\text{Supportive-A}}$		$\alpha_{\text{Motivation}}$	
		<i>SR approach</i>	<i>Vignette approach</i>	<i>SR approach</i>	<i>Vignette approach</i>
	Vignette approach	0.068	0.088	0.560	1.000

The sensitivity of convergent classification w.r.t the MMC threshold it informs us the significance of selecting the particular MMC value used here, which is, as mentioned earlier, a third portion of number line (numerically = 0.67, which is a third portion of number line of length $3.0 - 1.0 = 2.0$) corresponding to two single-step differences (e.g. [T,T,T] & [T,M,M] or [M,B,M] & [B,B,B]) in cross approach item responses. A tighter and a lenient MMC would respectively be 0.33 (where only one step difference in only one item is allowed e.g. [T,T,T] & [T,M,T] and hence it is the minimum possible margin) and 1.0 (where a single step difference is allowed for each item e.g. [T,T,T] & [M,M,M]).

Table A4 presents the results of this sensitivity analysis, showing that the primary conclusion, that the DAC scheme can classify a majority of students of the class with convergence holds in all cases (the worst case scenario is 15 students, which corresponds to 53.6% in the cohort of 28 students). The analysis also shows that, while the selection of minimum possible non-zero margin (0.33) naturally leads to a lower number of convergent responses; selecting a value higher than the next step of 0.67 becomes irrelevant as it has no effect on convergent cases. And this is again naturally expected because with an MMC of 1.0, even if a respondent fulfils the MMC criterion, the response is still likely to be discarded as the two approaches will be more than one category apart (thus not fulfilling the $M \pm 1$ convergence criterion) and therefore be declared divergent.

Table A4. Sensitivity analysis of convergent classification w.r.t MMC

MMC	Number (& %) of convergent respondents (% values are out of N=22 i.e. total self-assessment students)	
	$\alpha_{\text{Supportive-A}}$	$\alpha_{\text{Motivation}}$
0.67 (selected threshold)	21 (95.5%)	18 (81.8%)
0.33 (minimum non-zero margin)	15 (68.2%)	16 (72.7%)
1.0 (lenient margin)	21 (95.5%)	18 (81.8%)

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