STEM Education Review

REVIEW ARTICLE

Understanding the STEM student: Holistic strategies from social cognitive theory and the KAPA model of personality architecture

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ABSTRACT

This paper identifies and addresses two gaps that typically have separated practical needs in science, technology, engineering, and mathematics (STEM) education from basic psychological science research on non-cognitive factors in educational success. The gaps are: (1) educators want a holistic understanding of students whereas researchers commonly have explored isolated individual-difference variables; (2) educators need assessment procedures that are efficient whereas the most common holistic assessment technique, interviews, is time-consuming and thus inefficient. STEM educators can bridge both gaps by capitalizing on person-centered, idiographic assessment methods in personality science. Specifically, we explain how advances in social cognitive theory, its study of self-efficacy processes, and the person-centered social-cognitive approach known as the Knowledge-and-Appraisal Personality Architecture (KAPA) yield an efficient, holistic method of understanding individual students, their distinctive strengths and weaknesses, and their beliefs about STEM education challenges. We illustrate the theoretical principles through illustrations from ongoing STEM education research.

Key words: STEM education, social cognitive theory, perceived self-efficacy, Knowledge-and-Appraisal Personality Architecture model

INTRODUCTION

Governments and educational institutions worldwide recognize that effective science, technology, engineering, and mathematics (STEM) education is critical to economic growth and social well-being.[1] Efforts to promote education in STEM have two major foci. One is the curriculum. Educators aim to design classroom and laboratory experiences that optimally build students' scientific knowledge and skills.[2,3] The other focus is on the students themselves: the individuals who must decide to pursue a STEM education and navigate their way to success.

STEM students can be understood in part through assessments of their intellectual skills. But research indicates that non-intellectual qualities, often labeled "non-cognitive" factors, also significantly impact educational outcomes. In fact, non-cognitive factors are so influential that in some samples they out-predict IQ in studies of academic achievement.[4] The study of non-cognitive factors thus complements research on intellectual factors in psychology's studies of STEM education.

Despite substantial research on non-cognitive factors in STEM, there exist important gaps separating basic

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Received: 2 September 2023; Revised: 20 November 2023; Accepted: 24 November 2023; Published: 30 November 2023
https://doi.org/10.54844/stemer.2023.0465

research and educational practice. The purpose of the present paper is to identify two gaps that have received insufficient attention and to present a psychological assessment strategy that overcomes them both. The strategy is grounded in a well-known formulation in psychology, namely, social cognitive theory and its analyses of perceived self-efficacy.[5] We additionally draw on a framework that builds upon prior social-cognitive theorizing and broader advances in personality science.[6,7] It is the Knowledge-and-Appraisal Personality Architecture (KAPA), or KAPA model.[8–10] As we explain, the KAPA model has the potential to fill the two gaps between theory and research by providing STEM educators with a student assessment method that is research-based, efficient, and holistic. We illustrate the method with data from ongoing research.

VARIABLES OR PERSONS

One of the two gaps separating research and practice in STEM education involves a distinction between strategies of inquiry. Some strategies are "variable-centered" whereas others are "person-centered".[11] The gap is this. The vast majority of research studies are variable-centered, whereas educators call for a "holistic" understanding of students that inherently requires methods that are person-centered, as we detail below.

Variable-centered research and holistic advising goals

Variable-centered research follows a series of steps that surely are familiar to the reader. Investigators identify a non-cognitive variable of interest, select a survey to measure individual differences in this variable, and ask whether the non-cognitive individual difference predicts individual differences in educational outcomes. Often, they do. For example, variables such as conscientiousness[12] and "GRIT"[13,14] predict grade attainment.

Despite its many merits, this variable-centered approach fails to meet the recommendations of many educators. Writers contend that an optimal approach to promoting student success requires a shift in focus from variables to persons as a whole.[15] Any individual variable provides, at best, a fragmentary view of a person. But the promotion of STEM education, writers explain, requires a "holistic" view that "takes the whole student into account".[16] Particularly when student bodies are ethnically and socioculturally diverse, advisors are encouraged to "support the development of the 'whole person'—attending to the social, emotional, physical, psychological, economic, and other needs of the person" which requires one to "account for the holistic needs of learners through critical-ecological perspectives".[17]

A shift in focus from variables to whole persons is significant in practice because variable-centered methods cannot be assumed to fulfill holistic person-centered needs. For example, individual students may possess psychological qualities and confront psychosocial challenges that are not even represented on a set of survey items that is used to measure a selected variable. Furthermore, scholarship in psychometrics raises a measurement issue. The psychological variables that are identified in individual differences in populations cannot be assumed to describe the qualities of individual persons in those populations.[18–20] To meet educators' calls for a holistic understanding of STEM students, researchers need an alternative to the traditional method of ranking students on select individual-difference variables.

The challenge of idiosyncrasy

When seeking an alternative, one immediately confronts the challenge of idiosyncrasy. Most assessments of psychological variables are conducted "nomothetically". In the standard vernacular of psychology, nomothetic methods are ones that describe all individuals in a given population in terms of a fixed, "universal" set of psychological variables and assess each of those variables though a fixed set of test items.[21] But in efforts to understand the individual student, nomothetic methods are insufficient for two reasons.

One is that, as noted above, any given student may have personal preferences, beliefs, values, and life challenges that vary idiosyncratically from those of other students and are not well represented in the test-item content of a given nomothetic test. Research outside of educational contexts illustrates how the psychology of the individual and the structure of nomothetic personality tests may misalign. In this research, participants described their personality characteristics in their own words and then related these characteristics to everyday situations from their own point of view. Data analyses compared the views of each individual student to the structure of generic, nomothetic personality trait variables. Findings revealed that the self-described qualities of individual persons rarely aligned with the structure of the nomothetic personality traits.[22] The generic tests did not capture the distinctive qualities of individuals.

The second insufficiency involves the role of culture. A population of students may reside in a culture other than the one in which a psychological test was developed. If so, the structure of the original test may not generalize to the students' cultural setting. Findings involving Western psychology's most well-known assessment of personality, the assessment of "Big Five" personality traits, illustrate the point. Big Five variables repeatedly have been shown not to replicate cross-culturally.[23,24]

This set of considerations clarifies the first gap between theory and practice. The practical need to understand individual STEM students holistically is not met by the predominant research method of ranking students on generic, "all-purpose" nomothetic measures of selected variables.

THE CHALLENGE OF EFFICIENCY

The second gap in the literature involves a question of efficiency. The issue is a practical one: if researchers do develop a strategy for understanding individual students in depth, a strategy that meets the holistic need, will schools have the time and resources to execute that strategy?

The question is particularly important to STEM education for the following reasons. The alternative to the nomothetic tests critiqued above is an "idiographic" assessment strategy. The term "idiographic methods" refers to any of a variety of techniques that aim to understand individual persons as a whole, rather than merely describing individual differences among in a population.[25] Idiographic methods have the advantage of dovetailing with calls for a holistic approach to STEM student advising. But the most common of idiographic methods has the disadvantage of being inefficient.

This common idiographic method is interviews. Numerous education researchers have interviewed students, as well as mentors and teachers, to understand the distinctive psychological qualities of individuals engaged in education.[26–28] These research efforts have a clear implication: schools wishing to understand their students holistically can do so by interviewing all of them. This, however, commonly is infeasible. Interviews require school staff who possess interviewing skills, have the time to conduct formal interviews of all their students, and have the additional time required to code interview data to obtain succinct summaries of each student's strengths, weaknesses, and needs. At a great many schools and colleges, the time and resources required are simply unavailable. Thus, even if researchers develop an interview protocol that is useful for understanding STEM students, schools commonly will be unable to employ the method due to a lack of time and resources. This is the second gap that separates theory and practice.

How can researchers respond to the call for a holistic understanding of STEM students? What they must provide is a student assessment method that is person-centered, and thereby sensitive to the unique qualities of the idiosyncratic individual, while at the same time being efficient, so that the research-based assessment method can be put into practice. The purpose of the remainder of this paper is to describe to STEM scholars a recently developed method of personality assessment that meets these needs, and the psychological theory on which this assessment method is based.

SOCIAL COGNITIVE THEORY AND THE KAPA MODEL

The method we present is grounded in one of the most influential theoretical frameworks in the recent history of psychology, namely, the social cognitive theory of Albert Bandura.[5,29] Since the time of its development by Bandura in the 1980's, social cognitive theory has been widely employed as a theoretical framework to support research in numerous domains of study: health, organization, administration, sports, and educational success[30–33] including STEM education.[34–37]

Self-efficacy beliefs

In his late-career writings, Bandura emphasized that social cognitive theory is an agentic perspective on human nature.[5,6,38] As he explained, the capacity for intentional agency is derived from multiple psychological mechanisms that work together as a system.[5] Yet, among the multiple psychological mechanisms, one stands out as playing a central role in the exercise of human agency: perceptions of self-efficacy.

Perceived self-efficacy is defined as people's personal judgments (beliefs) about their capabilities to successfully execute acts in specified contexts. In other words, self-efficacy judgments are not beliefs about one's overall skill (*e.g.*, "I am a good student") but, instead, are appraisals of one's ability to take action to meet specific challenges (*e.g.*, "I am able to remain calm and stay focused during exams", "I am able to start class projects on time, with no procrastinating").

The empirical literature on self-efficacy is vast.[5,39] Research in domains such as self-regulated learning,[40] sports career planning,[41] career choice linked to STEM,[42] computational thinking and task value,[43] and education[44–46] document positive relations between self-efficacy beliefs and educational attainment.

Meta-analyses provide "overwhelming support"[47] for the hypothesis that academic self-efficacy beliefs influence school performance. In large-scale databases, it is not uncommon for self-efficacy measures to be uniquely predictive of success. For example, the singularly strongest noncognitive predictor of mathematics achievement in the Programme for International Student Assessment (PISA) database was mathematics self-efficacy.[48] Performance self-efficacy was the strongest correlate of grade point average in a meta-analysis of predictors of university GPA.[49]

Yet, even these valuable studies in social cognitive theory do not meet the holistic challenge noted above. Most extant self-efficacy studies are variable-centered; they rank participants, one versus another, according to their low or high beliefs in self-efficacy for educational attainment. Such studies commonly provide little information about why any given student has that low or high self-efficacy belief or how the individual student's self-efficacy beliefs may vary as they contemplate one versus another academic challenge. Methods deriving from the KAPA model aim to provide this additional person-centered information.

The KAPA model and its idiographic assessment strategy

The KAPA developed by Cervone[9] is a personality systems model that capitalizes on previous work in the social-cognitive tradition.[29] The feature of the model that is most pertinent to the present paper (and that gives the model its name) is the conceptual distinction between two aspects of thinking, that is, two qualitatively distinctive types of "non-cognitive" psychological variables: knowledge and appraisal.

In the KAPA model,[50] knowledge refers to mental representations of the attributes of entities that are relatively enduring. These include mental representations that center on one's personal attributes (including one's strengths and weaknesses) and knowledge of one's own aspirations (*e.g.*, mental representation of enduring life goal and long-term projects, such as entering into a career in STEM).

The term "appraisal" refers to ongoing evaluations of one's relation to the challenges and opportunities present in a given encounter.[50] Appraisal processes are dynamic, "online" cognitions that may change rapidly over brief periods; for example, a student at the start of an exam may have positive self-efficacy appraisals for test performance, but those self-appraisals may shift rapidly if they encounter an exam question that they do not understand. Laboratory research has long documented the impact of moment-to-moment performance feedback on appraisals of self-efficacy and of personal aspirations on a task.[51,52]

Two aspects of the KAPA model combine to open the door to the person-centered, holistic assessments that STEM educators call for. One is the recognition that knowledge structures influence appraisal processes.[53] In any given setting, one (or more) elements of knowledge may come to mind as people contemplate their present challenges, and these knowledge structures may shape their ongoing thought about (*i.e.*, appraisals of) the challenge. Consider again the hypothetical student who begins an exam with a high sense of self-efficacy but then encounters an exam question that they do not understand. If, at the time, the element of knowledge that comes in mind is a personal belief that "I tend to get anxious under stress", the student may ruminate on the difficult problem, become anxious, and perform poorly. But if the knowledge that comes to mind is "I am a creative person", that thought may prompt the student to see the problem as one to which creativity applies and to maintain a high appraisal of self-efficacy. The second pertinent aspect of the KAPA model is the expectation that the situations that activate one of another aspect of self-knowledge may vary idiosyncratically from one student to another. For example, imagine two students who both hold the belief that "I tend to get anxious under stress". For one, the belief might be triggered (or cognitively primed) when they encounter a difficult problem, but for another, the key triggering situation might be an interpersonal conflict at home that creates anxiety that interferes with studying.

These theoretical principles suggest an idiographic assessment strategy that is sensitive to idiosyncrasy in the content of people's beliefs and the situations to which these beliefs are relevant. The theoretical principles, in other words, move away from traditional trait-centered personality assessments, and toward a holistic assessment of individuals. This allows KAPA model assessments to capture the complexity and richness of human psychological processes in a way that closely aligns with the long-term emphases of social cognitive theory.[21] In doing so, it facilitates a contextualized understanding of individual psychological processes and recognizes that an individual's responses in a particular situation result from the unique interaction of their knowledge structures and social context.[8] Studies guided by the KAPA model have explored cognitive performance,[54] clinical assessment,[55,56] health,[57] addictions[58,59] juror decision-making,[60] and contextualized patterns of social behavior.[61–63] The execution of these assessments in the context of STEM education is described below.

OVERCOMING THE FIRST GAP: HOLISTIC ASSESSMENT

With this background in hand, we can return to the first of the two gaps between research and practice described above. The KAPA model methods do not merely assign to the student a single test score. They instead tap into multiple beliefs that are central to the individual, and the ways in which the individual relates these beliefs to a range of life challenges. This yields an assessment strategy that is person-centered and holistic—exactly the type of assessment that meets STEM educators' call for a holistic understanding of students. We will describe the strategy and then provide an illustrative result in the context of STEM education.

In a study of United States college freshmen in engineering, Cervone *et al.* conducted assessments with three features.[64] First, to assess students' knowledge (*i.e.*, their enduring beliefs about themselves and their educational circumstances), participants completed a narrative task in which they described, in their own words, their personal strengths and weaknesses, as well as educational supports and barriers in their educational environment. Secondly, to learn how individual students related their personal beliefs to academic challenges, participants completed a categorization task, that is unique to the KAPA model methods. In this task, individuals are asked to relate each element of self-knowledge (in this case, their self-identified personal strength, their self-identified personal weakness, and the identified support and barrier) to each of a series of specific academic challenges. The challenges included, for example, completing assignments on time, participating in class discussions, and maintaining physical health and well-being while in college.

The combination of these two methods yields individualized student "portraits". That is, one obtains, for each student, a depiction of that student's subjective understanding of themselves, their life circumstances, and their educational challenges. By creating these student portraits individually, rather than aggregating individual data into a population-level average, the methods bridge the usual gap between research methods and educators' desire for a holistic understanding of students. Figure 1 depicts the KAPA model strategy.

Finally, in the third part of the assessment battery, students completed measures of perceived self-efficacy. They rated their confidence in being able to act effectively to handle each of the series of academic challenges. Results strongly confirmed the KAPA model prediction that cross-situational variations in self-efficacy would be predictable (Figure 2). Students had much higher appraisals of self-efficacy in those situations in which they judged that their personal strengths and environmental supports were relevant.

OVERCOMING THE SECOND GAP: EFFICIENCY

The reader might object—and we would not disagree—that the KAPA model methods just described fill the first of the research gaps described above but not the second. The holistic assessment method employed by Cervone *et al.*[64] is not efficient. Administering the assessments required participants to travel to a lab, and analyzing the results and creating individualized graphical representations of a given student's social-cognitive system was a somewhat tedious data analytic and graphic-creation process.[64]

We are, however, currently executing a research program that is dramatically more efficient and that fills the second gap. Although the project is ongoing, and the present paper thus is not a formal report of study results, we feel there is value to bringing these promising methods to the attention of the STEM community.

The project investigates self-efficacy beliefs in writing, reading, and mathematics among high school students from public schools in the state of Sao Paulo, Brazil. One of the phases of the research executed the KAPA model assessment strategy used previously.[8,64] The limitation of prior studies, the inefficiency of their data collection and analytic procedures, was circumvented in the following manner.

We employed a software tool that administered all elements of the KAPA model assessments and auto-generates infographic displays that summarize the social-cognitive belief systems of the individual student (Figures 3 and 4, the software is publicly available at https://seeyesapp.com/seedegree/). Assessments were organized around six challenging domains in the academic environment: organizing study conditions; maintaining health and well-being; motivating oneself to study; overcoming doubts about one's ability, including through social support; understanding material in classes and attaining high academic performance. For each, software delivered the battery of qualitative and quantitative methods that comprise the KAPA model assessment strategy.[65] Participants rated self-efficacy for meeting academic challenges in the domain and the domain's importance (*i.e.*, its subjective importance to them). Students also described their personal strengths and weaknesses and related those qualities to behavioral challenges in each domain; specifically, they judged whether the personal attribute (strength, weakness) enhanced, impaired, or was irrelevant to the domain. Figure 4 illustrates the holistic portrait of one student that our method yields (data collection procedures were conducted in Portuguese, figures in this paper have been back-translated to English).

Figure 3 represents what a student who was selected for the purpose of this report, Participant 84 in our data set, reported as his personal strengths (Figure 3A) and weaknesses (Figure 3B). As characteristics of his personal strength, the student reported empathy, education, and will. Furthermore, the student positively related these qualities to multiple domains related to the study: obtaining social support to overcome personal doubts; understanding material in classes and academic disciplines; being motivated to study; maintaining health and well-being; and academic performance. That is, the

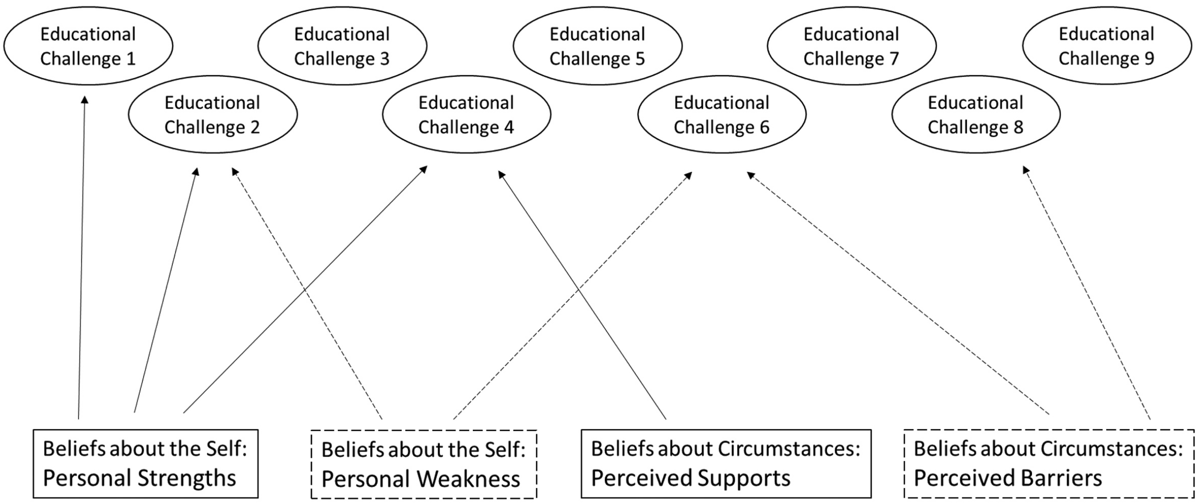

Figure 1. Schematic illustration of the Knowledge-and-Appraisal Personality Architecture (KAPA) model strategy. The central theoretical claim is that as students contemplate (or "appraise") any given academic challenge, their thoughts may be influence by pre-existing beliefs about themselves and their education environment (or elements of pre-existing "knowledge"). That aspect of self is relevant, may vary idiosyncratically from one student to the next. These theoretical ideas underpin the assessment strategy outlined in this paper, which is sensitive to idiosyncrasy in the content of beliefs and the social contexts to which they apply. In the figure, boxes represent elements of enduring knowledge, ovals represent challenging situations and associated actions, and arrows represent subjective links between the beliefs and the situated educational challenges for a given student. Reprinted with permission from Cervone *et al.*[64]

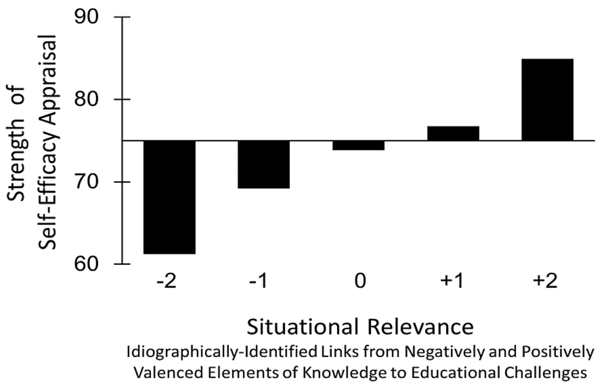

Figure 2. The figure displays STEM students' mean levels of self-efficacy in situations linked to positively and negatively valenced elements of knowledge. The numerical codes (-2 to 2) indicate the degree to which a given situation was linked, by a given participant, to positively or negatively valenced knowledge elements. As shown, self-efficacy appraisal varied systematically within persons, across situations, and this across-situation variability in appraisals was predicted by KAPA model assessments, specifically, assessments of students' subjective beliefs about their personal strengths and weaknesses and about the supports and barriers to STEM education success present in their environment. Reprinted with permission from Cervone *et al.*[64]

student saw a direct link between their positive emotional qualities and their academic performance. As shown, their level of self-efficacy was low for behavioral challenges in the domains of class understanding and academic performance. The characteristics reported as personal weaknesses were feeling alone and infatuation, which were negatively related to academic performance, motivation to study, and overcoming doubts, but even so, the student reported feeling confident to accomplish behavioral challenges in this domain. In sum, idiographic methods and infographic displays provide a holistic portrait of a student who sees their primary personal qualities as involving their emotional life, yet who also sees direct relations between these emotional qualities and the challenges they face as a STEM student.

Figure 4 presents a second student report, Participant 83 in our dataset. He reported that among the characteristics that represent his personal strength are dedication, organization and commitment. These characteristics were, in his view of the relation between his personal qualities and educational challenges, positively related to the domains of organizing conditions to study, maintaining health and well-being, and the other domains indicated in the left panel of Figure 4. He considered these domains to be highly important to him, as indicated by the subjective importance ratings. Yet, although important, his confidence in carrying out action in two of these domains was somewhat low (self-efficacy ratings of 80% or below). Turning to the personal weakness report, the student reported that his personal weaknesses are impatience, fear, and shame. He related these negative emotional qualities to a somewhat unexpected domain, not overcoming doubts or health and well-being but, instead, the domain of being motivated to study.

In the hand of a wise academic advisor, these KAPA-model idiographic portraits could facilitate a more detailed holistic understanding of students. Specifically,

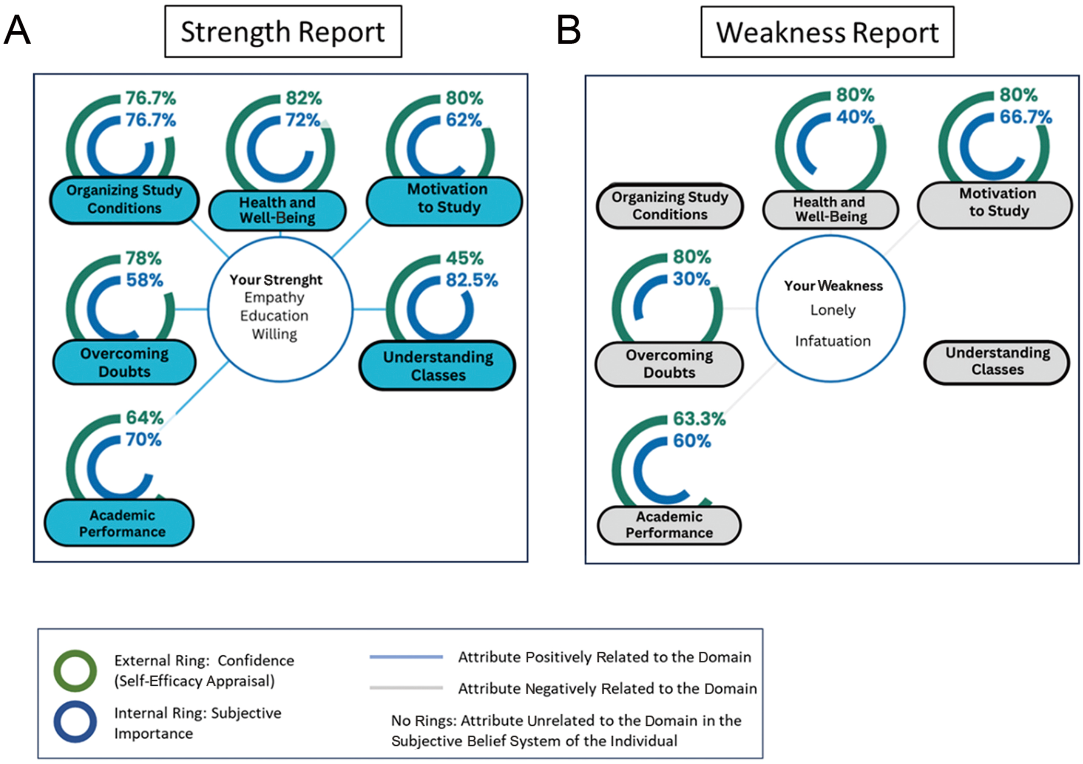

Figure 3. Infographics represent belief systems of an individual STEM student (in this case, Participant 84 within our overall data set). Central circles display personal attributes that the given student identified as personal strengths (A) and personal weaknesses (B). The (maximum of) six ovals label six challenging domains. For each domain, survey methods present multiple specific challenging behaviors within the domain. For each behavior, participants rate their level of perceived self-efficacy for meeting that challenge and the subjective importance of that challenging behavior to them. The length (and corresponding numbers) of the green and blue circles respectively mean self-efficacy and importance ratings for those challenging behaviors. Lines from the central circle to outer circles indicate the given participants' subjective belief about whether and how their personality attribute (strength or weakness) bears on their capacity to meet challenges in the domain (note that importance and self-efficacy calculations for a given domain are averaged across the subset of domain-linked challenges for which the participant judged their personal attribute to be relevant, which explains numerical variation across strength and weakness reports within a given domain). The infographics commonly reveal unexpected relations between personal attribute and academics. For example, this participant related tendencies to experience positive and negative emotions (empathy, loneliness) not only to social and emotional challenges (overcoming doubts) but also to academics (academic performance).

the reports are suggestive of distinctive aspects of the students' life that one might explore in an advising session. Regarding the personal strengths report (Figure 4A), the fact that the student sees himself as committed and organized yet has somewhat low self-efficacy for studying suggests that he may be facing external conditions that are out of his control and impair his ability to study. Regarding personal weaknesses, the absence in the students report of a link from self-describe negative emotional qualities (fear, shame) to emotionally pertinent domain (overcoming doubts, maintaining well-being) might be read as suggesting that the student may not be fully aware of the implications of his emotional qualities; the negative emotional qualities the student reports can impair well-being, but the student does not acknowledge an emotion-well-being link. When reading such student reports, one must recognize that they represent subjective beliefs not objective facts. KAPA model methods enable advisors to see the student as they see themselves. The student, of course, may have imperfect insight into the opportunities that their strengths afford and the difficulties their personal weaknesses may create.

We note a limitation of the present assessment methods that involves the age, and associated cognitive abilities, of the students being assessed. KAPA model assessments rely on the capacity to self-reflect and to articulate those self-reflections in words. Those capacities of course are possessed by the high school and college-aged students in our programs of research. The assessment methods, however, would not be applicable at much younger ages at which students lack the cognitive capacity to reflect deliberately on their personal qualities and the fit between those qualities and prospective academic challenges.

We have called the methods that yield the student portraits in Figures 3 and 4 "assessments". Yet, that term underestimates the overall nature and virtues of our procedures. The term academic "assessment" generally refers to a process through which institutions learn about their students. But in our automated KAPA model assessments, students also learn about themselves

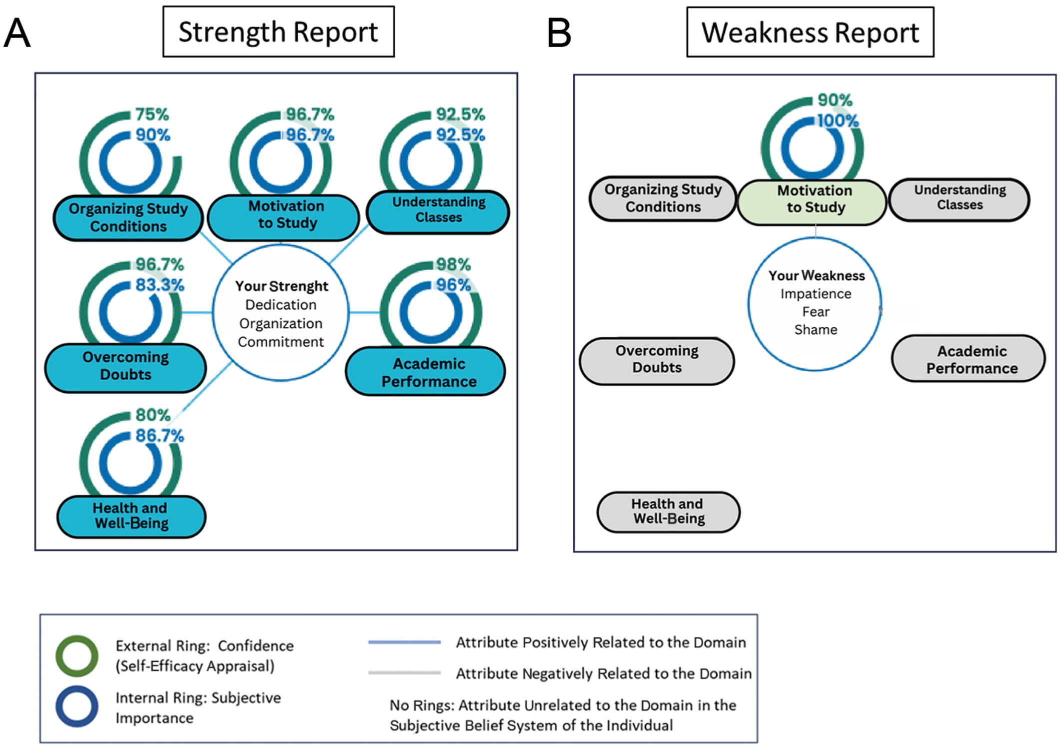

Figure 4. Infographic representation of the belief systems of a STEM student, Participant 84 within our overall data set. All visual representations are the same as those described in Figure 3. The representation displays a student who is highly dedicated to academics and sees himself as having organizational skills (A), yet (perhaps because of environmental circumstances) still is not confident of being able to create conditions that facilitate studying. The student is confident in sustaining his motivation to study, yet recognizes (B) that the emotional tendencies that are his personal weaknesses have the capacity to impair his motivation for school.

in two ways. First, our methods prompt self-reflection. Students reflect on their personal qualities and deliberate on the fit between those qualities and challenges of school. The process is considerably more self-reflective than is the completion of a standard questionnaire because our process uniquely adapts to the individual student, whose self-identified personal qualities become aspects of the assessment process itself. Second, the infographic displays (Figures 3 and 4) are provided not only to the educational institution but also to students themselves; software displays personalized assessment reports to students immediately upon their completion of the assessment steps. Students and advisors thus share in their access to a formalized representation of the student's view of self and academic challenges.

CONCLUSIONS

Writers argue that, to promote student success in STEM, educators “must take a more holistic and ecological view of...students”.[15] When educators have turned to psychological science to meet this need, they commonly have encountered psychology research methods that do not meet it because the methods are neither holistic nor ecological. This essay has reviewed theory and research that bridges this gap between basic research and practical needs. Idiographic assessments grounded in social cognitive theory[29] and the KAPA model of personality architecture[8] provide not only a conceptual framework but also a specific methodology for holistic assessment. Unlike methodologies that exclusively employ standardized questionnaires, the methodology we have outlined is sensitive both to the unique qualities of a given academic setting and the unique strengths and needs of individual students in that setting.

Our methods centered not only on social-cognitive systems in general but, more specifically, on students' appraisals of self-efficacy. As is documented by research reviewed above, self-efficacy processes have far-reaching implications for students' academic performance, resilience and career trajectories. This is true both when students encounter academic challenges and also, prior to that, when students select the challenges that they will encounter in the future; self-efficacy beliefs are a significant determinant of career choice.[41] When thinking about this psychological process, one must recognize that self-efficacy beliefs are contextualized and dynamic. As Bandura[5] emphasized, and as research repeatedly demonstrates,[25] a given student's appraisals of self-efficacy can vary substantially from one situation to another. Future research should focus on developing assessment tools that are more comprehensive, specific and situated in a sociocultural context, in order to capture the multidimensional nature of self-efficacy in STEM education.

The KAPA model offers guidance for such further developments. It employs research strategies that are centered on the person and are sensitive to social and individual contexts.[8] Aligned with the social cognitive theory, the KAPA model contributes to the understanding of how cognitive structures and processes interact to build the interpretations we make about things, reflections about ourselves, emotional experiences, and actions we perform locally.

Having overcome the two gaps separating research and practice, holistic focus and efficiency, the next challenge moves to the institutions that offer STEM courses. Schools need not restrict themselves to assessment methods that merely assign to the given student a score on a generic individual-difference variable. As we have shown, methods are available that yield a much more holistic understanding of students and the contexts in which they live. Use of such methods can enable institutions to better develop support mechanisms for students and to match existing institutional resources to the individual student's needs. KAPA model methods are one effective way to achieve the efficient yet holistic understanding of STEM students that educators desire. In closing, we note that rapid advances in large language models place into the hands of educational institutions, both large and small, the capacity to analyze the quantitative and qualitative data yielded by KAPA model assessments. There is no need to rely exclusively on traditional assessment methods that reduce students to a decontextualized, generic set of numbers. The day when holistic, contextualized student assessments can readily be administered and analyzed has arrived.

DECLARATIONS

Author contributions

Iaochite RT, Cervone D, Azzi RG: Writing—Original draft, Writing—Review and Editing.

Source of funding

This study was supported by the Sao Paulo Research Foundation (FAPESP # 2022/04585-2) for Roberto Tadeu Iaochite.

Conflict of interest

The authors have no conflicts of interest to declare.

Data sharing

Data used to support the findings reported here are available from Roberto Tadeu Iaochite (roberto.iaochite@unesp.br) upon request.

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