Guiding Empowerment Model: Liberating Neurodiversity in Online Higher Education

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***Abstract*—In this innovative practice full paper, we address the equity gap for neurodivergent and situationally limited engineering or computing learners by identifying the spectrum of factors that impact learning and acknowledging the fluctuations of learner function. Educators have shown a growing interest in identifying learners' cognitive abilities and learning preferences to measure their impact on academic achievement. These needs, however, are often addressed via one-size-fits-all approaches leaving the burden on disabled students to self-advocate or tolerate inadequately conducive conditions for their learning. Emerging frameworks guide the support of a neurodiverse learner population in curriculum and assessment activities through instructional approaches, such as online education. However, the application of these frameworks is disaggregated, and the technology interventions recommended for the online learning environment remain insubstantially supportive resulting in disparity, particularly for those with undisclosed learning or developmental disabilities and situational limitations. In this article, we integrate a neurodivergent perspective through secondary research of around 100 articles to introduce a comprehensive Guiding Empowerment Model involving key cognitive and situational factors that contextualize day-to-day experiences affecting learner ability. We illustrate the model by synthesizing common formations of these factors to facilitate three sample student profiles that highlight fluctuating user perceptions and explore initially evident actionable user problems in functioning. We use this model to evaluate sample learning platform features and other supportive technology solutions that potentially address the needs of the neurodiverse learner population represented in the learner profiles. The proposed approach augments frameworks such as Universal Design for Learning to consider factors including various sensory processing differences, social connection challenges, and environmental limitations. We suggest that by applying the model through technology-enabled features such as customizable task management, guided varied content access, and guided multi-modal collaboration, major learning barriers of neurodivergent and situationally limited learners will be removed to activate the successful pursuit of their academic goals.**

***Index Terms*—Design-based research, Students with disabilities, Distance Learning, Educational Technology [syn: E-learning], Socio-technical thinking**

I. Introduction

Neurodivergence [1], [2] is becoming an increasingly necessary consideration when designing learning experiences. Historically, support for neurodivergent students has been referred to student disability offices in higher education institutions that require official diagnoses before support is rendered [2], [3]. While often withheld from those without a documented diagnosis, accommodations can be ineffective [4] or irrelevant even for those with the proper documentation resulting in reduced help-seeking behaviors in at-risk neurodivergent students [5], [6].

Prior work has expounded on the disparity neurodivergent students face when pursuing STEM education [7], [8] in particular, and solutions have risen such as online learning [9] which offers flexibility for learning time and place, cognitive styles [10] that involve the various ways learners process information, and Universal Design for Learning [11] which aims to increase access and participation to meaningful learning experiences. However, there is a gap in describing effective implementation for these largely content-focused, instructor-led instructional approaches with learners who require more personalized or adaptive support in an online asynchronous environment.

The authors seek to address this inequity through the synthetization and application of a Guiding Empowerment Model. The model is based on secondary research of evolving educational theories and practices and is comprised of 31 scaled environmental and cognitive factors that impact meaningful learner interaction and progress. This practice endeavors to achieve several goals by addressing various dimensions. Firstly, it applies an underlying conceptual model to identify and justify the essential needs of neurodiverse learners in an asynchronous online competency-based learning environment. Secondly, the practice explores these needs through the lens of three distinct sample personas, providing insight into their diverse requirements. Lastly, the practice outlines a process that detects learner needs using analytical software, implements effective support systems, and facilitates timely accommodations within the learning platform via digitally surfaced resource recommendations to increase momentum particularly for learners exhibiting characteristics that resemble neurodivergent traits. A variety of exploratory technical solutions are introduced as components of the learning support system. This article addresses the contextual barriers neurodivergent STEM learners face in their academic pursuits by proposing strategies for deliberate and active organizational commitment to the equitable academic achievement of a neurodiverse learner population.

II. Relevant literature and existing practices

A. Neurodiversity

Neurodiversity, which describes the spectrum of cognition and behavior across both neurotypical and neurodivergent individuals [1], [2], is a key factor in learner efficacy. While some view neurodivergence as a deviation from typical cognitive processing and environmental response [12], others, particularly within the neurodivergent community, argue these differences are natural variations along the Human Spectrum [13]. Nonetheless, neurodivergent learners often struggle to succeed in conventional higher education settings despite accommodations and face a higher risk of burnout and other mental health effects [3].

B. Online learning approaches

Online learning at the college level has become pervasive [14] and, more recently, synonymous with education, primarily due to constant technological advancements. No-code online authoring and delivery solutions [9] enabled transformative, scalable, and equitable learning approaches [15], [16]. One such approach, competency-based education [17], [18], emphasizes the practical application of acquired skills and offers greater flexibility and adaptivity [19] to diverse learner populations [20] via self-directed, asynchronous online learning [21].

C. Cognitive Styles

Not to be confused with learning styles which sort learners into static categories of instructional modes [22], cognitive styles distinguish three key cognitive spectra: field dependence or independence which refers to learners' tendency to think about the big picture versus small details, holistic or analytical thinking, and reflective or impulsive thinking [10]. This approach has been used to support students in traditional instructor-led classrooms and recently in a case of chatbot-assisted content delivery [23] but has not been widely applied in an asynchronous online competency-based university setting for computing or engineering students.

D. Neuro-inclusive Instructional Approaches

Often learners without a documented disability who experience cognitive or environmental challenges [24], [25] are left to manage their challenges on their own or via inadequate supports [5]. Additionally those eligible for accommodations face lingering challenges [4] in the university setting. Two instructional approaches that incorporate inclusivity and learner wellbeing needs have emerged as transformative to educational equity: trauma-informed instruction [26] and Universal Design for Learning (UDL) [11], [27], [28]. Trauma can manifest in a variety of behaviors that impact academic achievement such as social avoidance, impulsivity, distractibility, inflexibility, and risk-taking challenges [29]. Trauma-informed instruction acknowledges educators' responsibility to disrupt the systems enabling trauma by structuring new, equitable learning experiences that consider learners' holistic needs. Educators cannot distinguish between learners with non-apparent disability or trauma and those without these circumstances [30], so a human-centered lens must shape their instructional approach.

The Universal Design for Learning (UDL) framework, which is grounded in extensive literature on the educational needs of neurodivergent students, embodies inclusive learning design [11] by providing multiple means of representation, engagement, and expression to accommodate the variability of a diverse learner population. Some key principles of UDL are providing multiple formats of instructional materials such as both auditory and visual information, facilitating learner development of executive function skills through agency [31], and developing learners' self-awareness and regulation strategies. While growing evidence documents the positive effects of implementing trauma-informed instruction and UDL on learner achievement [32], and specific strategies exist for supporting engineering students through UDL [33], these frameworks are based on a synchronous, instructor-led environment and provide limited direction for addressing a nuanced and complex adult online learner population who may face a variety of distinct socioeconomic, neurocognitive, and social factors that can impact learner progress [6], [24]. There is also a gap in guiding the prioritization of impactful academic technology solutions to support learners based on their fluctuating needs. In previous work, sensory differences [34]–[36] in particular have been associated with varying levels of impulsivity, rejection sensitivity, overactivity, multitasking [37], demand nonconformity [38], and adaptability [39]. Sensory differences can also affect individuals' isolation from social support [40]. For example, they may experience challenges in social interaction, emotional regulation, and help-seeking or teamwork behaviors required for academic performance and be more likely to drop out of educational programs [41]. Recurrent sensory challenges and discomfort may also cause anxiety, stress, and avoidance [42] or avoidant-perceived behaviors [6] impacting learner wellbeing and academic performance [41]. Learners' ideal environments may vary from day-to-day, so educators must explore interventions that both give learners agency and support to modify their environments to suit their own fluctuating sensory needs [11], [31], [43] and anticipate those fluctuations to adapt instruction automatically [19].

III. Guiding Empowerment Model (GEM)

Guiding Empowerment Model (GEM) is a conceptual framework that compiles secondary research to highlight the day-to-day cognitive and environmental factors that contextualize [44] learner functioning and behavior and identify actionable problems mitigable through technical solutions. Apparent disability, non-apparent disability, and situational limitations all can fluctuate along a spectrum, causing variations to the way online learners interact with their environment, other people, and their course materials. GEM identifies 31 dynamic characteristics described in the literature as essential to how learners process new information. It can be used to detect and address learner needs by applying UDL and trauma-informed practices through technological supports such as AI-guided learner choice [23]. Table I categorizes these 31 scales into

TABLE I
THE SIX CATEGORIES AND 31 SCALES OF GUIDING EMPOWERMENT MODEL

GUIDING EMPOWERMENT MODEL
Time and Energy Physical engagement. Mental engagement.
Sensory Processing Visual seeking (high to low), Visual avoiding, (high to low) Auditory seeking (high to low), Auditory avoiding (high to low) Tactile seeking (high to low), Tactile avoiding (high to low).
Social Cognition Rejection reactive to rejection persistent, Demand conforming to demand avoiding, Social connection desire to social avoidance, Empathy to apathy, Social stability to social flexibility.
Reasoning Adaptivity to rigidity, Emotional thinking to critical thinking, Decisive to indecisive, Less risk comfort to more risk comfort, Reliability to impulsivity.
Executive Function Time management ability, Hyperfocused to distractible, Multitasker to single tasker, Memory, Repetitive tasking to varied tasking, Big picture oriented to detail oriented.
Core Skills Subject matter efficacy, Written language, Spoken language, Technology efficacy, Self awareness.

six interrelated groups: time and energy, sensory processing, social cognition, reasoning, executive function, and core skills.

A. Time and Energy

This category pertains to how learners expend their time and energy throughout their day. Various day-to-day environmental and internal factors can influence the engagement and momentum of online learners [45]. While learners in an online cohort are all assigned the same duration to complete their courses, they may have varied actual time and energy [46] to spend on study-related activities due to other commitments of daily living [47], and the physical environments where learners spend their days may imply varied situational needs. Factors such as interruptions, distractions, or fatigue [48] can affect how productive a learner is in progressing toward their academic goals [49]. Learner life in terms of time and energy represents physical engagement and mental engagement. Some tasks require both physical and mental exertion such as caregiving. Some require high mental engagement but low physical engagement such as job-related web-calls, and some require physically demanding but less mentally taxing tasks such as driving or running. A learner's free time, a potential opportunity for study can be impacted not only by time spent on these other tasks leading to fatigue [38], but also by the physical environment surrounding their free time, whether it is conducive to focus or fogged up by distracting sensory stimuli. While educators may struggle to mitigate the environmental barriers in online learners' study spaces, this article suggests several tools and policies that can support learners challenged by distracting environments of study.

B. Sensory Processing

Sensory processing refers to the ways [49] the nervous system receives and interprets sensory information from the environment [50] to enable meaningful interaction with the world [51], [52]. Differences [35], [53] in sensory processing can affect behaviors [44], [54], [55] at times impairing learner ability [56]. Sensory processing theory describes four distinct patterns of response to sensory information in the environment: Sensory avoiding, a tendency to actively avoid or experience discomfort with certain sensory stimuli [55]; sensory seeking, a tendency to seek out intense sensory experiences; sensory sensitive, a heightened reaction to sensory stimuli; and sensory unregistered, a lessened awareness or minimal response to sensory input [54], [57]. An individual's sensory orientation can vary based on situational or environmental factors and may fluctuate over time [44], [58] without their awareness to its impact on their ability to adhere to the norms [38] of academic pursuit [20]. GEM defines the Sensory Processing category as learners' visual, tactile, and auditory reactivity patterns which directly [41] and indirectly [12], [38]–[40], [42], [59] relate to learner retention in academic programs.

C. Social Cognition

Appropriately applied social interaction in learning environments is positively associated with academic achievement [60]–[63]. The Social Cognition category is defined by five scales: rejection reactivity, demand responsiveness, social connection desire, empathy, and social continuity. Rejection reactivity measures the degree to which learners react to rejection and failure [64], [65], both socially and cognitively. Demand responsiveness measures learner performance of conformity and compliance to instructions and expectations [12], [38], [60], [66], [67]. Social connection desire measures the degree to which learners actively seek out and desire help, social opportunities, and a sense of belonging from peers and faculty in the online university setting [61], [67]–[69]. The Empathy scale characterizes more collaborative [70] interactions [45] for learners with the ability to attune to the feelings and perspectives of others and respond with compassion [71] avoiding both overaccommodating and indifferent detachment [72]. Social continuity measures learners' levels of saturation in stable and enduring social relationships [73] outside the university setting as well as their bandwidth in forming and maintaining new bonds [41], [74].

D. Reasoning

The Reasoning category is comprised of five cognitive scales essential to student success [75]: flexibility of thought, emotional-rational balance, balanced decisiveness, risk inclination, and engagement consistency. Flexibility of thought measures the degree to which learners can adapt [3], [45] their thinking and beliefs in response to new information or changing circumstances [38], [76] to solve problems. Emotional-rational balance is defined by the range between the subjectivity of emotional thinking and the at times detached [45] banality of overly logical thinking contributing to a learner's overall emotional intelligence [70], [77]. The balanced decisiveness scale assesses learners' ability [79] to make timely and effective decisions in support of their academic goals [24], [80]. The risk inclination scale measures learner comfortability [81] with risk-taking [82]. Engagement consistency contrasts learners' observable or perceived tendencies toward reliability [61] versus impulsivity [83], [84] in their academic performance [55].

E. Executive Function

The Executive Function category is comprised of five scales related to learners' efficiency: time management ability, concentration, task approach, memory function, and systems thinking. The time management ability scale measures the effectiveness [5], [38] of learners' internal capacity for organizing, planning, initiating and following through on academic commitments [85], differentiated from their observable engagement consistency. The concentration scale is defined as a learner's range from hyperfocus to distractibility [38], [86]. The task approaches scales consider learners' tendencies toward polychronicity (multitasking) versus monochronicity (single tasking) [38], [76], [87], [88] and toward accessing repetitive or ritualistic behaviors in support of their learning [66] versus varied activities and approaches. The memory scale is defined by a learner's working and short-term memory capacity [89] and its impact [90], [91]. The systems thinking scale measures learners' granularity of focus, whether they are conscientious of small details or more big-picture-oriented [92].

F. Core Skills

The final category of GEM considers learners' foundational efficacy [93] in core skills for academic success [94] including familiarity with the field of study, literacy, verbal articulation and comprehension, technology, and the learners' own self-awareness. The field of study scale measures learners' efficacy with their subject matter at the start of their program and continually. The literacy scale measures learner confidence in reading and writing at the expected level of the established language [95]. The verbal articulation and comprehension scale measures a learners' ability to express themselves through spoken word and understand spoken language effectively [96], [97]. The technology efficacy scale relates to a learner's proficiency in and access to using varied and evolving digital tools and resources for academic purposes [98]–[100]. The self-awareness scale assesses learners' understanding of their own strengths, weaknesses, and learning requirements [20].

IV. Personas

In order to evaluate the breadth of GEM and illustrate the model through context, problems, and needs, this section introduces three sample learner profiles Fig. 1 (see figure after References). The authors opted not to reference clinically-defined neurodiversity in the personas, focusing instead on specific factors that influence learning experiences. This perspective acknowledges that neurodivergent individuals can often be indistinguishable from neurotypicals and seeks to avoid perpetuating stereotypes by not adhering to restrictive definitions of spectrum conditions.

The first learner profile, Persona 1 needs energizing rituals. They are tenacious and friendly. They use breaks and wait times throughout their daily activities for energizing learning activities that prime them to study deeply later at a designated workspace. They seek social interactions with their online school community preferring spoken interactions and audio options for course engagement. Their impulsivity and distractibility may hinder effective time management, causing missed scheduled live events or risky decision making. However, they recover from rejection or failure with notable resilience.

The second learner profile, Persona 2, values personal autonomy and freedom deeply and is highly sensory and rejection sensitive. In their quest for control, they may face challenges when required to follow specific directions or solve problems in a prescribed manner. They often structure their own study approach and schedule, for example learning constantly in small chunks while on-the-go. They leverage their technical skills to customize their digital learning experience to suit their ongoing fluctuating needs though their self-awareness may occasionally be insufficient for them to recognize those needs. Finding spoken and auditory communication challenging, they prefer anonymity in social situations or opt to avoid them altogether while also taking pride in their reliability, not wanting to let others down. However, this penchant for independence may lead to high burnout potential due to over-commitment and frequent multitasking.

The third learner profile, Persona 3, prefers the familiar. They rely on a prescribed structure and very clear directions for their learning, often seeking guidance from traditional instructors. They compartmentalize academic and personal relationships and seek social support outside formal academic settings. They typically react neutrally to sensory stimuli, and they are equally comfortable expressing themselves in various communication modalities. Strong time management skills and a stable, dedicated workspace enable them to stay focused on academic tasks for extended periods of time though they may exhibit a lack of adaptability to changes in routine, environment, or learning platforms. However, they are typically aware of their limitations, such as technical skills, and seek assistance proactively when necessary.

V. Decisions and Alternatives

The three sample learner profiles characterize examples of the distinct and diverse momentary, fluctuating [58], and static needs of learners in an asynchronous online competency-based learning environment. A four-step process is outlined to address these needs at scale and facilitate inclusive educational experiences: 1) identify learner behavioral patterns; 2) identify learner contexts when exhibiting the behaviors; 3) integrate a system of holistic learning support; 4) combine behavioral data and ongoing context data to surface just-in-time support tool recommendations for a learner.

A. Step 1: Identify learner behavioral patterns

The initial step involves examining learner behaviors in the online platform such as engagement (i.e. how frequently and for how long learners engaged with the learning platform and accuracy of formative and summative activities attempted). Educators will implement learning platform telemetry and instrumentation augmented by generative AI [23] to identify learner behavioral patterns and technical problems.

B. Step 2: Explore learner context patterns

The second step explores the contextual underpinnings to learners' behavior. Educators will introduce frequent in-platform checkpoints from the point of orientation and throughout the program of study. These checkpoints will include psychometrically-validated questions aligned to the GEM scales to interpret fluctuating learner mindsets and environments. The results will continually evaluate the effectiveness of GEM and the prioritization of the factors to be addressed, leading to prioritized technology enablement needs for students with neurodivergent traits that would otherwise be unsupported.

C. Step 3: Integrate systems of holistic support

Building a culture of inclusive thinking for student support and supportive technical tools involves both enabling supportive technical capabilities and reframing [71] faculty and staff mindsets to a trauma-informed lens [26]. Some possibilities initially identified through examination of the personas for technology support include customizable digital experiences, multi-modal collaboration, enhanced assessment experience, note-taking task scheduling, and AI-assisted co-regulation. Customizable digital experience enables the learner's ability to adjust key aspects of the learning platform such as background and font color, font size and type, haptic settings, and read aloud functions. In multi-modal collaboration, instructors engage with learners using learners' preferred communication modes including text, email, voice, or video. These same options are available for peer connections and collaboration via an online staff-moderated virtual community space. The virtual community space supports both course and program spaces as well as student extracurricular or special interest support spaces. Enhanced assessment considers rejection reactivity within formative and summative assessment feedback (including trauma-informed proctoring) and enables various modes of formative activities for access across devices. Note-taking enables annotation and commenting within the learning materials along with a summary area where those notes can be viewed, searched using keywords, or exported and shared with peers, faculty, and other apps on the learner's device as requested. Task scheduling enables a checklist view of all tasks for a course or program, a calendar view with scheduling and exporting of tasks and events, and digital reminders and alerts for tasks and activities suggested by the platform or created by the learner. AI-assisted co-regulation refers to modeling emotion identification and productive coping to guide learners in developing self-regulation skills, such as through the use of a sensory diet [71].

D. Step 4: Implement guiding empowerment

In the final step, behavioral data and ongoing contextual checkpoint data are combined to identify and surface the data-informed, tailored support tool recommendations to address learners' evolving needs and challenges. For instance, Persona 1 may benefit from customizable task scheduling and alerts, read-aloud functions, and quick haptics-enabled formative practice activities accessible on mobile devices. Persona 2 may benefit from modifiable content background colors, trauma-informed proctoring, and text-based peer and instructor engagement and course materials. Lastly, Persona 3 may benefit from structured task scheduling, technical support, and a higher degree of consistency across their program.

E. Generative AI

Generative AI should be considered as an interwoven method to guide [23], [101] learners by identifying and recommending highlighted learning and support tools as the continuous learning capabilities of these systems will sustain scalability. For instance, the checkpoints in Step 2 could trigger a notification for an instructor to make contact with the student using a specific mode and tone or trigger direct intervention from the platform itself in the form of automatic alerts, personalized content and experience, and other guidance.

VI. Limitations

Learners' data security, human quality checks of AI recommendations, and the specifics of the learner support system are all facets of this approach that must be carefully considered and defined in implementation. Learners must opt-in to their data being tracked and receiving data-adjusted experience recommendations. The format of the frequent checkpoints in the platform must not distract or impose on learners. The platform experience (e.g. the activities recommended, the course material and assessment modes, the course community activities highlighted, and the communication modes by instructors) should adapt dynamically based on learners' ongoing responses rather than categorizing them into one static persona or profile. GEM is an exploratory conceptual model that must be tested in practice empirically before the impact on learner achievement can be determined.

VII. Conclusion

This article has offered researchers and online education providers an approach to a deliberate, active commitment to equity within a neurodiverse learner population that has historically excluded and under-supported neurodivergent learners and those with situational limitations [102]. The authors advocate for learners' dignity, informed agency, and accommodations in the ways they study and live and propose that addressing the contextual needs computing and engineering learners face while studying in an online, asynchronous, autonomous learning environment will improve the achievement of not only officially diagnosed neurodivergent learners but also those with undiagnosed cognitive challenges or situational limitations. Furthermore, this article has suggested a process for identifying the various fluctuating needs these populations may face and for building systems of equitable learning support and a culture of inclusivity and data-informed personalization.

VIII. Disclosure

The first author discloses as a diagnosed autistic person and a member of the neurodiversity movement, an identity that affects the interpretation of the secondary research compiled and the perspectives expressed in this article.

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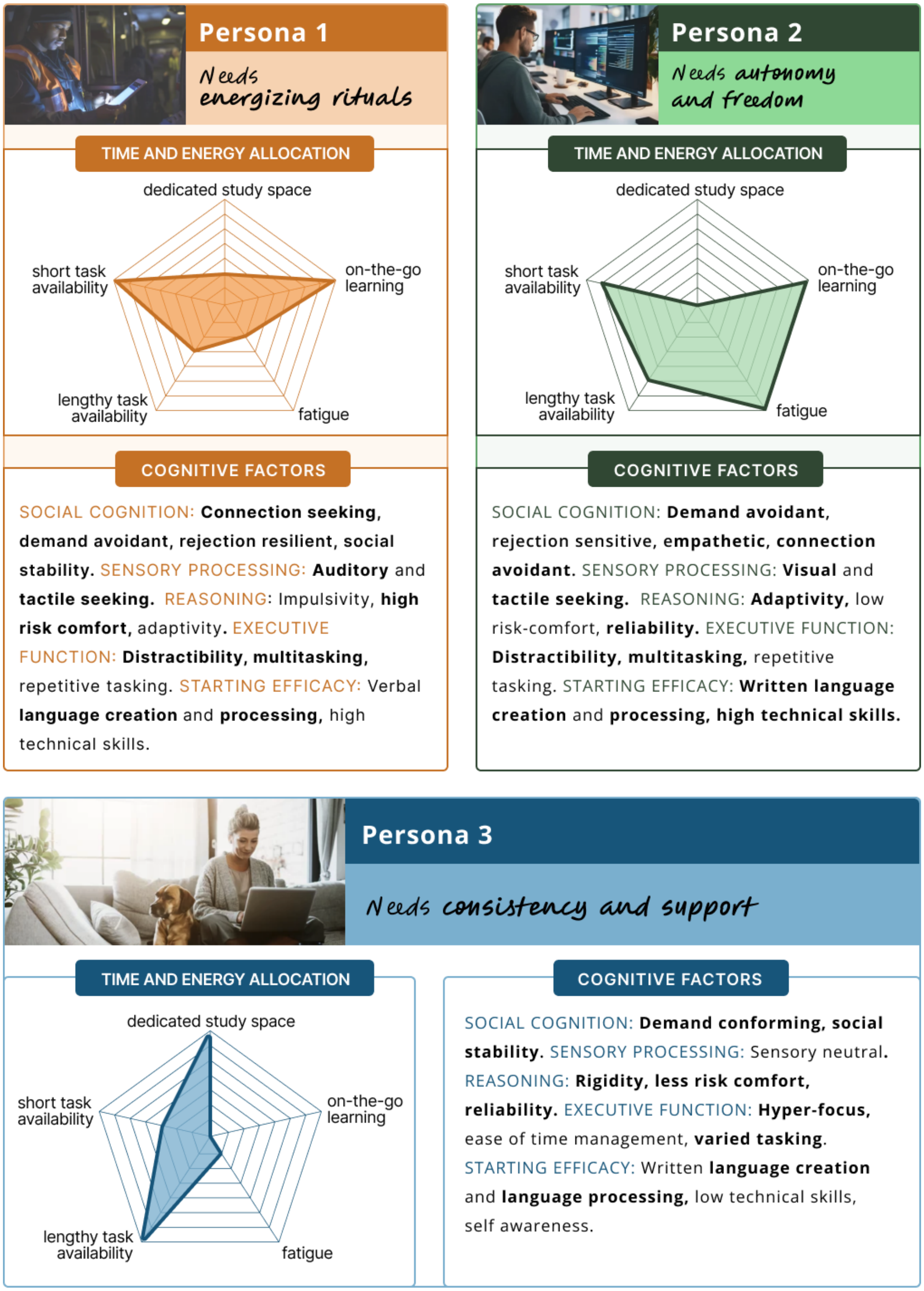

Fig. 1. Three sample personas: Persona 1 - ”Energizing Rituals,” Persona 2 - ”Autonomy and Freedom,” Persona 3 - ”Consistency and Support”