Assessing Motivation to Individualize Reinforcement and Reinforcers for an Intelligent Tutor

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Abstract. Personalized learning with technology is in full demand across all context. Learning occurs through motivation therefore, personalizing motivation is key to enhancing learning rate and retention for the learner. Supplying the intelligent tutors with key information not will advance the familiarity of individual's motivational factors and interest for individualizing motivation. Building this relationship stems from a streamlined Motivational Assessment Tool (MAT), aimed at assessing several motivation factors. The Motivation Assessment Tool is based on the interconnectedness of motivational factors with personality. The creation of the assessment allows the intelligent tutor to implement reinforcers that influence motivational level based off individual variances such as personality.

Keywords: Motivational factors · Intelligent tutor · Individualized motivation · Personality · Motivation Assessment Tool

1 Introduction

Personality traits and motivation impact learning strategies and outcomes [1]. They are titled as separate entities, yet interconnected by similar influential factors. Personality traits set the tone (positive or negative) that influence motivation by pre-disposing the individuals to be more or less comfortable in different types of situations and activities. Motivation increases or decreases as a person involved in an activity that is compatible or incompatible, respectively, with their unique make-up of personality traits. With respect to learning, the compatibility of the learner's personality traits and learning environment impacts the learner's motivation. Consequently, learners benefit from instruction that is tailored to their personality traits and motivation levels.

Motivation and personality are both complex because they are influenced by various factors. Personality traits are generally stable and unchanging, although outward

display can vary across short timespans depending on the environmental context [2]. Motivation also changes based on a person's value [3], relevance of the activity [4], interest in the subject matter [5], ability to persist [6], and level of support needed on a task [7]. The use of a motivational strategy that recommends reinforcers that leverage the learner's personality traits and level of intrinsic motivation can support and increase the learner's motivation. The Motivational Assessment Tool (MAT) will perform an upfront assessment of the learner's personality and motivation. The results can then be used to determine what type of reinforcers to provide and a schedule for providing reinforcement. For this specific effort, the MAT will feed into the Generalized Intelligent Framework for Tutoring (GIFT) long term learner model [8] to recommend a personalized motivation strategy. The goal is to provide an extended representation of motivation pursuing personalized motivation though an assessment.

2   Personality Interaction with Motivational Factors

Research has investigated correlations presented in motivation, interest, and personality. The interrelationship of personality, motivational variables, and interest are recognized, but not fully established. Personality traits describe relatively fixed attributes that shape how an individual perceives and interacts with their environment. Consequently, an individual's set of personality traits often influence the types of activities they pursue [9]. One of the most commonly used set of personality traits is the Big Five [10–12]: Extraversion (preference for active/social environments), Agreeableness (preference for cooperation vs. competition), Conscientiousness (preference to attend to details, self-focused), Neuroticism (predisposed to viewing the environment as negative or threatening) and Openness (preference to try new things, creative). Motivation refers to an individual's desire and drive to succeed, or in this case, to learn, and has been categorized into two types: intrinsic and extrinsic. Intrinsic motivation refers to an internal desire to achieve, while extrinsic motivation refers to the situation in which the individual requires an external source that compels them to achieve [13–15]. Examples of the interaction between personality traits and motivation include individuals high in Conscientiousness tending to be intrinsically-motivated, while individuals high in Agreeableness (and low in Conscientiousness) tend to be extrinsically motivated. In addition to the interaction between personality traits and motivation, other attributes compound to further influence a learner's motivation. In order to develop a method for assessing motivation and determining an appropriate reinforcement strategy, the linkages between motivation and personality traits were further decomposed and defined by values, reinforcement sensitivity, vocational interest, and learning styles.

Values refer to what a person finds important [3]. Values are a part of personality and associated with motivation. Something an individual values also serves to motivate. For example, individuals with high Extraversion value social interaction [16] and are motivated when in social environment. Values and motivation are formed partially from their environment [17, 18] or from genetic factors [19]. Research has also supported that vocational interest are pieces of a person's personality [20, 21]. Table 1 identifies the linkages found between each of the Big Five personality traits and values, using the Schwartz Value Theory to define value.

A person's vocational interests reflect their personality. For example, individuals low in Extraversion prefer solitary activities, and therefore, their interests tend towards activities with low social interaction [9]. Self-efficacy [22] and interest also remain connected [23] and therefore, personality is connected to self-efficacy [24, 25]. The relation to self- efficacy is possibly through relations to the variables of personality or possibly an extension of one's personality. [24, 25]. Vocational interest is included in the Motivation Factors Interdependencies shown in Table 1 given that training with an intelligent tutoring with respect to GIFT is vocationally focused. Also, a learner's vocational interest provides insight into types of reinforcers for that individual.

Reinforcement Sensitivity Theory (RST) [26–28], which proposes that motivation is changed by a person's sensitivity to rewards (SR) and punishments (SP), explains a person's personality behaviorally and physiologically with respect to the provision of reinforcements in learning. For example, individuals with high Conscientiousness are highly sensitive to punishment, which would be viewed as a criticism of the perfection they strive to achieve, whereas they have little sensitivity to rewards since they are pushing themselves to achieve internally. Table 1 further describes the relationship between RST and the Big Five personality traits.

Deep level learning versus surface level learning has also been connected to personality types [29]. Understanding an individual's proclivity towards surface or deep learning is important when considering an intelligent tutor environment to ensure the information is being conveyed in a manner that is compatible with the learner's style. Further, ensuring that the format of the instructional content is provided in either a deep versus surface level format is important to keeping the student motivated with the learning task. Consequently, the relationship between deep versus surface level learning, referred to as learning style, is included in Table 1.

All of this research seem to point in the direction that personality is interconnected with facets of motivation. When combined, these interdependencies add more pieces to the puzzle when determining a person's motivation. However, providing a big picture, by stringing all the pieces together for a complete representation of a person's motivation by personality has yet to be determined. Table 1 shows some of the different interdependencies between the Big Five personality and motivational variables at a high level and how placing the research together begins connecting the pieces towards a more complete view of an individual's motivation.

Table 1. Interdependencies of motivation factors to personality.

Motivation					
Openness	Conscientiousness	Extraversion	Agreeableness	Neuroticism	[10–12]
Stimulation, self-direction, hedonism, universalism and benevolence. negatively with conformity, tradition, and security	Conformity, security, achievement, and to a lesser degree tradition. negative to hedonism and stimulation	Stimulation, self-direction, hedonism, power, and achievement. negative to conservation, tradition, and conformity	Strong link for benevolence and universalism. Negative link to power and achievement	No links	Schwartz value theory [3, 30, 31]

(*continued*)

Table 1. (*continued*)

Sensitivity to punishment is negatively associated	Sensitivity to punishment is positively associated. negatively associated to sensitivity to reward	Positive correlation to sensitivity to reward and negative to sensitivity to punishment	Associated positively to sensitivity to punishment and negatively to sensitivity to reward	Sensitivity to punishment and reward is positively associated	Reinforcement sensitivity theory [26–28 47–49]
Investigative, social interest, and artistic	Conventional interest, and stability	Enterprising and social interest	Low relation to social interest	No links found	Vocational interest Holland (RIASEC) [20, 21, 32, 33]
Positively relates to all 6 self-efficacy types	Related to social, enterprising, and conventional self-efficacy	Related to artistic, social, and enterprising self-efficacy	Related to social self-efficacy	Negatively related to investigative and enterprising self-efficacy. Lower self-efficacy for 5 out of 6 RIASEC types	Self-Efficacy and interest Holland (RIASEC) [21, 22, 24, 25, 34, 46]
Prefers a deep learning	Strategic and deep approach to learning	Deep and strategic	Results are not consistent	Prefers surface level learning	Learning Style [1, 35]
Connected with intelligence and GPA. [36] Like more open assessments that not analytic, concise, or multiple-choice [37]	Associated with Grit [38] and negatively to procrastination [39, 40, 45]. Prefer continuous assessment [37]	Grade dependent on the type of assessment. Oral exams, short-multiple choice, and group work. [37]	Relation to oral exams and group work [37]	Has ties to procrastination. [39, 40] tendency towards being negative [41] Prefer assessment to not be continuous low Neuroticism associated with essay or oral exams. [37]	Other

Each of these factors identified in Table 1 have a separate assessment. Some of the assessments look at one factor value, such as procrastination while others combine a few factors. While the interconnectedness is not completely understood, acknowledgement of their connection is agreed upon [1, 29–33, 35, 45–49].

3   Creation of the Multifactor Motivation Assessment

As shown above, research has provided overtones from personality with motivation factors. This interrelationship between the factors of motivation and personality provides similarities on all their assessments. This connected relationship is key for

developing an assessment that covers the multidimensional approach for assessing motivation. The relationship is key for developing the new assessment because it allows it to be pared down and streamlined while still capturing the variables presented in the interconnected factors for an intelligent tutoring system.

3.1   Specific Development of the Motivational Assessment Tool

To begin the process, foundational work needed to be established from prior assessments, reinforcers, and taxonomies. This was prepared by creating a list for each of the sections and used to guide in the formation of the Motivational Tool Assessment (MAT). During the creation of the tool, a layout of the assessment was established. The assessment layout consisted of a list of factors in the assessment, which included demographics and interest. The foundation of the tool identified analogous structures between the assessments. The discovery of the related structures was accomplished by color-coding by motivational variable type (e.g. intrinsic, student autonomy) and listing items from each assessment, about 500 question/statements in all. Then the assessment questions/statements were clustered together by similarities. The clustering yielded the questions that were connected. During this process, we also discarded any motivational question/statement that did not apply to an intelligent tutor or teaming situation. Teaming was eliminated because of the current capabilities of the intelligent tutor of interest. Similar questions were rewritten into one or two questions. The motivational type categorizations were merged in some cases because of different connections in other areas. However, categorizations that appeared distinctly different remained separated. These motivation factors are related but still separate entities. Some of the questions that only applied to one motivation factor remained if applicable. A new, comprehensive assessment was generated from this qualitative factor analysis process.

The resulting MAT areas that did not capture a person's full motivation because it left out the link to their interest. Consequently, a list of reinforcers was assembled from different context and interest inventories, such as the Dunn-Rankin Reward Preference Inventory. [42]. Both non-tangible (e.g. on-line scorecard) and tangible (e.g. paper based scorecard) were included. An intelligent tutor can integrate and present many of the non-tangible reinforcers such as digital tokens, recognition, or brain breaks. However, tangibles require an onsite human teacher to provide the reinforcer in a timely manner. Therefore, the use of tangibles will be added by the instructor's availability of the items to bridge the barrier for supplying these types of reinforcers that are given very selectively. It will remain available for situations that are capable of blended learning approaches. Otherwise, it will remain off when a trainer is not available. It was noted that some pieces of information were required for the intelligent tutor to tailor and reinforce motivation. Therefore, we added sections to the MAT that is addressed in the gap areas, which will further guide the intelligent tutor towards maintaining a desired motivation level.

3.2   Gap Areas in the Motivation Assessment Tool

While aligning the assessment categories, there were some categories that had many fewer statements than others. To help improve the reliability of the MAT, additional

items were recommended for these smaller categories- specifically in the goals/task and reward orientation sections. Another gap was the lack of specificity in the assessment items to develop actionable reinforcement strategies. The questions were then geared towards personal learning styles, choices, and strategies learners require to achieve maximum learning and retention to aid in determining the best means of providing reinforcement to the learner. Some of the sections were included to specifically gain insight on the learner's strategies for retention. This enables the intelligent tutor to provide support to a person's motivation and preference to be challenged, while also helping him or her to be a successful learner.

The task section was included to help, providing personalization to the task to influence motivation. Examples of this type of personalization are: (a) providing the learner with an option to pick the level of complexity they need to reach the goal: (b) displaying questions prior to the task, or just after the task, to help maintain focus during the learning session or after learning; (c) proving an outline to help them or preference to take their own notes, and (d) increasing the type of learning such as video, text, or listening. Some examples of the statements learners were asked to rate themselves on are:

1. In order to understand the content, I need information from different sources.
2. I am able to focus better when the text is provided to me in smaller amounts.
3. I am able to learn information faster by watching a video.

These types of questions are geared towards self-regulation and organizing preferences that have an impact on motivation. Knowing the way a student learns and the type of strategies that help learners to retain information and work hard is key in this section. Assessments of learning style exist, but were not specific enough to reinforce with an intelligent tutor, so questions were developed to help tailor motivation on a smaller scale.

The other gap in the available assessment dealt with rewards. In particular, a reward orientation section is included in the MAT. The aim for this section was to provide insight into an individual's competition perspective, types of recognition preferred (anonymous, informal, ranking, and recognition by peers), leaders, points, reinforcers, and frequency of praise or feedback needed. Tendencies towards ascetics, progress bars, type of guidance needed, grades, and unexpected rewards etc. This allows the computer to select from the taxonomy the type of rewards of interest and other functions that would enhance learning.

3.3   Linking the Motivational Assessment Tool and the Implication

After the MAT questions were solidified, each assessment item was liked to one or more of the five personality traits. By determining the association with an assessment item and a personality trait, the number of potential reinforcement's strategies suitable for the individual can be reduced. The goal of this is to make judgments prior to the data analysis after data is collected. The Intelligent tutor then has a wealth of knowledge on the person and their thought process for motivation. To prep for linkage, an organizer was created based on the Five Factor Personality model [10–12]. Then, judgments on the connectedness to personality for each motivation assessment

statement were made. There were a few statements applicable to all personality traits. Personality can also be linked to many of the reinforcers. As previously discussed, a preference for reinforcement through the use of social recognition is linked to individuals high in Extraversion [9]. Another example pertains to a brain break reinforcer that is administered to help regain focus for individuals that are impulsive or easily stressed as seen with high Neuroticism or low Conscientious personality types. Personalities that are high in Openness are linked with artistic interest and low Extraversion prefer independent activities. There are some additional small links towards physical activity, musical preference etc. with personality [43, 44]. However, the research is very limited in linking specific reinforcers to personality. That limitation is one challenge that will be addressed by the development of the MAT. Other individual differences will also be considered for motivational links. These differences will be asked during the demographics sections. Factors that may influence a person's motivation other than personality is their social economic status, GPA, or type of community the individual lives in (rural, suburban, or urban). As with the qualitative factor analysis completed for personality and motivation, the same type of process can be applied here. These other considerations will direct us to motivate more specifically and begin to drill down on individual differences and personalizing reinforcers towards them by a more robust picture of a person.

Once the assessment is distributed to analyze the data, a taxonomy that stands across context will be hunted. Current taxonomies are divided by peer approval, tangibles, non-tangibles, etc. [42] However, without linkage to personality trait, this does not allow for personalization that may occur across the taxonomies. For example, the learner may be motivated by tangibles and peer approval equally. The data provided from the assessment will guide the creation of a taxonomy that will allow more personalization of reinforcers. Once the MAT taxonomy is created, it will be implemented into specific task experiments to test its validity and into the GIFT platform. Physiological measures will be collected to obtain data for measuring states of motivation during the task and effect of different reinforcers.

4 Next Steps

The next step is to incorporate the use of real-time physiological measures to evaluate student engagement and activity levels to provide additional inputs to the intelligent tutor to further refine the reinforcement strategy selection. This physiologically-based assessment of engagement will alert the tutor to different states, such as high stress, frustration, or boredom. Identification of real-time engagement between the different states will allow the intelligent tutor to determine the optimal strategy for supporting the student's motivation – such as providing motivational reinforcement or initiating an intervention. It may be possible in the future to link dopamine release with another physiological device that is cheaper and more accessible such as the FNIR, skin conductance, heart rate, or eye blinking.

With respect to rewards and reinforcement, a future effort is to determine the value of each reinforcer based on personality. This project will validate a select few reinforcers although there are a multitude of reinforcers available. Knowing the effect size

for each personality will give the intelligent tutor input on what reinforcer will boost the learner to an optimal learning state. If the physiological measure detects only a slight decrease from the pendulum then the effect size needed is small as well. If the tutor does not provide anything, the motivational gap will increase and effectiveness of the motivational reinforcer will need to be larger.

The last step to be expanded is perfecting the intelligent tutor's capability with in the zone of proximal development. The intelligent tutor cannot just provide the student the right answer when they are wrong. There needs to be a balancing system that challenges the learner. This also could be linked with physiological measures. For example, if the brain is not showing maximum effort then the intelligent tutor will redirect the learner to try again versus another person might need more assistance. The high level of stress would tell the intelligent tutor that this learner need more guided support or to back up to the previous concept. This requires incorporating real-time assessments that distinguishes different engagement states and provides a deeper level of understanding for motivation and learning strategies needed for the learner.

5   Conclusion

The demand for personalized learning is in full force across context. Motivation allows for learning and success to occur. It too, is an individualized process. Finding a proper fit that is relevant to the learner is key. This process begins by creating an assessment tool that streamlines important relationship factors that an intelligent tutor cannot form without being provided the information. This enables the development of a taxonomy of reinforcers that personalizes methods for the intelligent tutor, which can boost an individual to optimal motivation. This assessment, links to individualization, and prior research provides a vision of a framework for personalizing motivation by personality. This framework provides guidance on effective reinforcement schedules and applies the reinforcer immediately. It directs learners in a path towards increasing the learning rate and retention. Ultimately, accomplishing this effort will result in learning that is accessible to all and deployed from the Long Term Learner Model within GIFT tutoring system.

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