



Exploring social problem-solving profiles among Hungarian high school and university students

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ABSTRACT

Treating social problem-solving as a construct comprised of a number of components enables us to examine patterns formed by the components. However, variable-centered research has paid little attention to exploring these patterns to date. A person-centered approach may enable us to identify distinct profiles for groups. Our study aimed to investigate whether it is possible to establish homogeneous profiles for groups based on social problem-solving factors (positive and negative orientation, rationality, impulsivity, and avoidance). Furthermore, the study sought to explore whether there is any difference among these groups regarding self-efficacy, a fundamental component of social problem-solving. We used cluster analysis to examine social problem-solving and self-efficacy among 543 Hungarian secondary school students and 277 Hungarian university students. We identified three homogeneous groups that had shared characteristics in the two age samples (optimistic-hasty; optimistic-reflective; resigned-procrastinator). Four further groups were identified among adolescents (resigned-distancer; insecure-reflective; insecure-hasty; resigned-brooder); and an additional three among young adults (optimistic-modest; tense-hasty; tense-reflective). The relationships among the social problem-solving factors and self-efficacy differed among the profiles. Taking into account the profiles explored in this study may help identify groups that need improvement, and contribute to interventions being better suited to the needs of a particular group.

1. Introduction

Our approach to social problems and the style we use to solve problems—which we jointly refer to as “social problem-solving”—determine how our relationships develop and how we function in groups, and these factors influence our academic and professional progress and even our psychological well-being [1,2]. Models of social problem-solving (e.g. Refs. [1,3,4]) agree in describing it as a cognitive-emotional-behavioral process on the one hand, and as a unity of orientation and a problem-solving process on the other. Treating social problem-solving as a construct comprised of a number of components enables us to examine patterns formed by the components. Previous research using the variable-centered approach (e.g. Refs. [1,2,5,6]), however, has devoted little attention to investigating these potential patterns. The variable-centered approach is only of limited use in examining the relations

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between components, and it may also be misleading in exploring the existing links between social problem-solving and other variables. In addition to potentially producing a more precise picture of the connections between social problem-solving and its correlates, using a person-centered approach may aid in identifying groups requiring development, and could also contribute to making interventions better fit the characteristics of members of a particular group. The research described in this study had two aims: to investigate typical profiles among adolescents and young adults based on social problem-solving orientation (positive or negative) and problem-solving style (rational, impulsive, or avoidant), and to analyze whether there is a difference between these profiles in terms of one of the key elements of orientation, self-efficacy. Developmental programs based on the variable-centered approach are less likely to take into account crucial individual characteristics in social problem solving (e.g., the close association between negative orientation and avoidance, which cause significant difficulties in life management). It was assumed that a person-centered approach would reveal profiles that would help to understand the individual characteristics and their relationship, so that prevention and developmental programs can be better targeted, especially towards appropriate social adjustment.

1.1. Social problem-solving

A social (or interpersonal) problem is any social task, situation, or relationship—which can be understood to be in the past, present, or future—whose source is either the individual themselves or another person (or other people). A social problem generally prompts unpleasant and negative thoughts and feelings in the individual, which mostly, although not necessarily, stimulate the individual to take steps to resolve the situation, and/or mitigate or eliminate the negative thoughts and/or feelings so they can experience effective social functioning, accommodate their environment optimally, and achieve their goals [7,8].

The attempt to resolve a social problem is a cognitive–emotional–behavioral, mostly conscious process [9]. This process is divided into two parts in most models: the orientation part and the problem-solving part [9–11]. The orientation part of the process involves sensitivity to the problem, commitment to a solution, and self-efficacy, and it can be positive or negative: We can approach the situation optimistically, even interpreting it as a challenge; we can believe in ourselves; and we can assume that the person we are dealing with is likewise willing to solve the problem [11]. On the other hand, we can also be pessimistic, and we can doubt ourselves and the other person, having little tolerance for the frustration caused by the situation [11].

In the problem-solving part of the process, we define the problem, seek alternative ways of solving it, assess these ways in terms of their potential consequences, and then decide which one to use, at which point we implement it, i.e., we solve the problem [9,12]. D’Zurilla et al. [9] distinguish three general styles—rational, impulsive, and avoidant—which can be combined in a problem situation based on the features of a particular situation, the problem, and those involved. The *rational problem-solver* concentrates on the facts, considers several possible solutions and their potential consequences, is interested in the other person’s opinion, communicates assertively, asks a number of questions, is curious about the other person’s position, and is occasionally slow to precisely decide due to their thoroughness. According to Siu and Shek’s [13] research, positively oriented and rational problem-solvers are characterized by a higher degree of empathic concern and perspective taking than impulsive and avoidant problem-solvers [13]. An *impulsive problem-solver*’s thinking and behavior are mainly determined by negative emotions. They tend to concentrate on their own goals and interests, decide quickly, act hastily, take few alternatives into account, and barely consider potential consequences if at all, and their behavior may frequently turn aggressive. The *avoider* either does not begin dealing with the problem, or, if so, they soon give up, exit the situation, and are characterized by a very small sense of responsibility. According to Frauenknecht and Black [3], one’s problem-solving style is increasingly context- and person-specific as one grows older, and with time, it is increasingly determined by past experiences (habits, patterns, and frequently used techniques), which can simultaneously influence the orientation and problem-solving phases as an unconscious process.

Based on previous findings (e.g. Refs. [2,9]), one’s orientation process basically determines their problem-solving style. In other words, how we solve a social problem, what emotions we experience in the meantime, and what we are thinking as we act, fundamentally depend on how we approach the problem and the other person, how much we believe we can resolve the situation, and what we believe about our self-efficacy. The consistent finding of studies conducted in groups of various ages is that a positive attitude is most frequently paired with a rational style, and that a negative attitude is followed by an avoidant or impulsive style. At the same time, an increasing number of analyses (e.g. Refs. [14–16]) stress that orientation–style relations paint a far more varied picture (e.g., a negative orientation paired with a rational style), and that this variety is particularly common during adolescence.

According to results from studies of adolescents (e.g. Refs. [2,9,17]), a negative orientation becomes increasingly common, and the frequency of a positive attitude drops from the ages of 12–13 years, the reasons for which are new interpersonal problems that emerge with adolescence and a shift in their orientation and the world (peers and adults). Although there are cultural differences (e.g. Ref. [18]), most studies suggest that negative attitude is most characteristic of 13–15-year-olds and girls, while the relation with avoidance is steadily strengthened at the ages of 13–14 years among boys. A rare orientation–style relation, in which a negative orientation is paired with high rationality, can mainly be found among adolescent boys; this is also often linked to avoidance. Based on this chain of relations (negative orientation–rationality–avoidance), it can be assumed that (1) there are certain positive characteristics of a negative attitude for the individual, a result of which the process does not come to an end (immediate avoidance with strong impulsivity), or (2) avoidance does not proceed immediately from the negative attitude (avoidance then results from a conscious, reflective decision). It can thus be assumed that having a negative orientation is not dysfunctional in every case, because this system of relations and its manifestation in one’s behavior lead to positive results (or that is what the individual hopes), which may have a significant self-defense function [6,19]. In a study with Palestinian and Hungarian adolescents, this triad (negative orientation–rationality–avoidance) was present among Hungarian students but not among Palestinian students, while a strong association between negative orientation and impulsivity was much more common among Palestinian students [20].

Findings from studies involving young adults (20–25-year-olds) (e.g. Ref. [7]) paint a less unified picture of social problem-solving, which Chang et al. [7] believe is explained to a greater degree by cultural differences in socialization than it is for adolescents. According to certain studies (e.g. Ref. [7]), problem orientation varies less and can be viewed as being more stable by young adulthood, with differences rather showing in the frequency of problem-solving styles. At the same time, based on a study by D’Zurilla et al. [21], the degree of negative attitude drops by young adulthood; for young men, as with adolescent males, this is closely tied to the growth in frequency of rationality-based problem-solving. Ptacek et al. [22,23] also point out that young men are more optimistic in their problem-solving than young women.

1.2. Self-efficacy

Self-efficacy denotes the belief or conviction that a person is capable of coping with stumbling blocks that may arise, because they have the necessary resources and skills [24]. According to Bandura’s [25] social cognitive theory, personal ideas about self-efficacy stem from four sources: mastery experiences (e.g., previous successes and experiences), vicarious experiences (e.g., observing model persons), social persuasion (e.g., verbal encouragement), and physical and emotional states (e.g., experiencing stress or anxiety while completing a task).

A feeling of self-efficacy plays a key role in self-regulation. Our belief that we can reach the goals we have set influences our decisions, efforts, and aspirations in numerous areas in life. The feeling of self-efficacy has a significant effect on successfully coping with each challenge [26] and on psychological well-being [27]. People with high self-efficacy feel that they can maintain control of a particular situation—rather viewing each task as a challenge—are capable of attempting to reach a solution, have high self-confidence, and are less prone to stress and depression. In contrast, people with low self-efficacy are less committed to goals, and are less able to lose themselves in what they are doing; in addition, if they encounter a task or situation that is challenging for them, they experience it as a threat, and thus quickly shy away from solving the problem [28].

1.3. The link between social problem-solving and self-efficacy

One determinant of an adequate social life is the social dimension of self-efficacy—that is, how effectively someone can establish, nurture, and end relationships. Social self-efficacy can be defined as an individual expectation that emerges in interpersonal relationships [10], and these expectations may significantly determine the success of these relationships [29].

Self-efficacy is one of the central elements within the orientation part of the social problem-solving process [1]. In the case of social problem-solving, self-efficacy refers to the individual believing they can achieve the desired effect with their actions in a social problem situation, and they can influence their decisions, their aspirations toward a solution, and the level and degree of their efforts in particular activities. In problem situations, individuals with greater self-efficacy are more likely to believe they can control their own thoughts, and thus are more likely to attempt to solve the problem. People with low self-efficacy in a problem situation experience negative thoughts and feelings about themselves and the situation as well as about the solution (e.g., “I’m incompetent” and “I can’t solve the problem”) [30]. These negative thoughts and feelings result in the idea that the goal is unreachable, which plays a role in exiting the situation and giving up on the problem-solving process. This is particularly common in adolescence as part of a transitional period, in which there are numerous challenges and difficulties to cope with, and in which successful coping depends to a large degree on perceived self-efficacy [31].

Numerous previous studies have provided empirical evidence for a general relation between social problem-solving and self-efficacy (e.g. Refs. [32,33]) and a particular relation between domain-specific scales (e.g., Refs. [10,34]). In studies that have used the same instruments to measure social problem-solving and self-efficacy employed in this study, self-efficacy among young adults was found to correlate positively to a positive orientation and negatively to a negative orientation [10,32,33]. In addition, Lau et al. [32] and Erözkan [10] identified a positive relationship between self-efficacy and the rational problem-solving style. People with low self-efficacy tend to avoid social situations that cause unpleasant, negative feelings and thoughts, as they are often perceived as a threat. This shows that low self-efficacy is associated with an avoidant problem-solving style [35]. Parto’s [36] study with adolescents found that self-efficacy and social problem-solving are direct and indirect predictors of mental health.

1.4. The person-centered approach

The term *person-centered* covers a variety of statistical approaches (cf [37,38]). What is common to these approaches is that the participants in the research are organized into groups, clusters, classes, or profiles based on certain similarities and differences. These terms are frequently used in the same sense in research that employs a person-centered methodology.

The use of a person-centered analysis is typically justified among a wide range of researchers based on the limitations of a variable-centered analysis. At the same time, there are advantages and disadvantages to both approaches. First, which approach is adequate depends on the aim of the research; second, both procedures may be necessary to paint a full picture (cf [39]). In using the variable-centered approach, attention is placed on the relation among the variables in a particular sample. The person-centered approach focuses on profiles—that is, combinations of different variables that emerge in the various groups of cases (participants) in the sample. This enables the researcher to examine the size of the proportion of individuals with the same pattern as well as the degree to which some combination of the occurrence of the variables under examination is characteristic or special, among other areas [37]. Furthermore, the variable-centered approach enables the researcher to study the degree to which groups that have been identified differ regarding features characterized by one or more other variables (e.g. Ref. [40]). Individuals that fall into various groups

based on certain features may differ significantly regarding a further variable—in extreme cases, it is possible for a positive relation to appear as a negative relation, or vice versa, regarding a particular group—which may even result in a variable-centered approach not showing a relation among the variables under examination [38]. This approach has been used in numerous longitudinal studies to analyze the relative stability of patterns in a sample and the circumstances that bring about reorganization in the groups of individuals (e.g. Ref. [41]).

There is a small but steadily growing number of studies in which a person-centered approach was used in connection with some component of social competence. This approach is increasingly being used with group individuals based on problematic (e.g., aggressive) behavior (e.g. Refs. [42,43]) or risk factors (e.g. Ref. [44]). First, the approach may significantly aid in more easily identifying groups that need improvement. Second, it may contribute to interventions being better suited to the features and needs of a particular group. The latter is also advantageous regarding intervention impact assessment because the impact of each intervention can then be separately assessed in groups of participants with different profiles (e.g. Ref. [45]).

The person-centered approach is particularly apt for cases in which a certain feature of individuals is measured using several scales that are mutually independent, while the features measured by the scales cannot be viewed as mutually exclusive. The person-centered approach thus seems particularly suited to studying social problem-solving. To our knowledge, no person-centered analysis has been conducted to date with the measurement instrument we use in this study (Social Problem-Solving Inventory–Revised: [9]).

1.5. Research aims and hypotheses

The research reported in this study had two aims. One was to investigate whether homogeneous groups can be identified based on social problem-solving factors. We identified potential groups in a sample of adolescents and young adults in the interests of generalizability. The other aim was to ascertain whether differences in self-efficacy can be identified between potential groups formed based on social problem-solving factors. If a difference can be demonstrated between the groups in this regard, it will support the contention of examining social problem-solving relations with further variables with the person-centered approach in the future.

For the first research aim, we assumed that homogeneous groups could be identified in both age groups based on factors tied to problem-solving orientation and style. We thought that these groups would not only show a “classic” orientation–style relation (positive orientation–rationality, negative orientation–impulsivity, and negative orientation–avoidance) but also other patterns (e.g., positive orientation–avoidance). We further expected the profiles to be nearly identical based on our sample of high school and university students, because adolescent and young adult problem-solving would not differ significantly, with any differences rather found in the frequency of problem-solving styles and less so in orientation [7].

Regarding the second research aim, we assumed that there would be an identifiable difference between particular profiles tied to social problem-solving and self-efficacy, and that, where a profile is marked by a negative orientation and impulsivity, self-efficacy will be lower than in the case of a profile characterized by a positive orientation and/or rationality [32,33].

2. Methods

2.1. Sample

The sample is part of a longitudinal research program which investigates the transition to a new school level among secondary school and university students (see Ref. [46]). Our research used convenience sampling: a sample of ninth- and tenth-grade students from several counties in Hungary and first- and second-year students from a number of faculties at a Hungarian university. All the participants spoke Hungarian as a native language. Our analysis involved data from a total of 543 high school students ($M = 15.82$ years, $SD = 1.06$ years; $n_{\text{male}} = 212$, $n_{\text{female}} = 311$) and 277 university students ($M = 20.13$ years, $SD = 5.16$ years; $n_{\text{male}} = 101$, $n_{\text{female}} = 173$). The high school sample shows heterogeneity, with 61% attending a general school, 25% a technical school, and 14% a vocational school. The inclusion of high school students from various school types ensured the heterogeneity of the sample in terms of socioeconomic status.

2.2. Instruments

We used two instruments in the research: the Social Problem-Solving Inventory–Revised instrument (SPSI–R, [9]; Hungarian-language version: [47]) to measure social problem-solving and the Self-Efficacy Questionnaire [48] to assess self-efficacy. Both instruments have been employed in numerous previous studies among Hungarian adolescents and young adults (e.g. Refs. [2, 49]). The factor structure of the Hungarian-language version of the SPSI–R and that of the original instrument agreed in both the previous and present studies.

2.2.1. Social problem-solving inventory–revised (SPSI–R)

The original and the Hungarian-language versions contain 25 statements alike, with five factors (five statements per factor) measuring characteristics of social problem-solving regarding contemporary problems: positive orientation (e.g., “Whenever I have a problem, I believe that it can be solved.”) and negative orientation (e.g., “I get nervous and unsure of myself when I have to make an important decision.”), as well as rational (e.g., “When I am trying to solve a problem, I think of as many options as possible until I cannot come up with any more ideas.”), impulsive (e.g., “I am too impulsive when it comes to making decisions.”), and avoidant (e.g., “When a problem happens in my life, I put off trying to solve it for as long as possible.”) problem-solving styles. The statements were

rated on a 5-point scale (1 = not at all true of me; 5 = extremely true of me). The questionnaire was sufficiently reliable for both ages and for each factor (Cronbach’s alpha = 0.71–0.87).

2.2.2. Self-efficacy questionnaire

The single-factor questionnaire measures a comprehensive and stable sense of competence that arises in effectively coping with various stress situations. Ten statements (e.g., “I am confident that I could deal efficiently with unexpected events.”) were rated on a 4-point Likert scale (1 = not at all true of me; 4 = extremely true of me). The questionnaire was sufficiently reliable for both ages (Cronbach’s alpha = 0.86, 0.87).

2.3. Data collection and ethical permission

The study was approved by the United Ethical Review Committee for Research in Psychology (EPKEB) in Hungary (permit No. 2017/125). The participants and parents of the high school students received written information on the aims and implementation of the research. Informed consent was obtained from the participants and the parents of the high school students. Data collection among the high school students was supervised by their teachers, and by the authors in the case of the university students. We assured the participants, both in written and in spoken form, that their participation in the study would not influence the evaluation of their performance or their academic results, and that they would be able to stop participating at any time.

2.4. Statistical procedures

We conducted analyses tied to our research aim of identifying profiles in subsamples for the two age groups. Through the process, we formed profiles in two main steps regarding the orientation processes of social problem-solving (positive and negative) and general problem-solving styles (rational, impulsive, and avoidant). In determining the profiles, we first expressed the combined values for the five factors on standard scales, the means for which are 0 and the standard deviations for which are 1. During the first step, we used Ward’s minimum variance hierarchical clustering method [50,51] and the squared Euclidean distance [52] to conduct a hierarchical cluster analysis with the standardized variables. The aim of this analysis was to form initial clusters, identify cluster solutions, and determine the number of clusters that represent the data most accurately. Based on the agglomeration coefficients tied to the formation of the dendrogram and the clusters, we ascertained the number of clusters into which the participants under examination could be grouped (cf [53]). Then, cluster solutions were validated using discriminant function analysis [54], and we used a multivariate analysis of variance (MANOVA) to check whether a significant variance could be found in the clusters formed based on the social problem-solving scales.

We conducted a K-means cluster analysis (cf [53,55]) as the second step, the aim of which was to identify and characterize profiles tied to clusters determined during the hierarchical cluster analysis. During the process, we used a one-way analysis of variance (ANOVA) via the factors to examine the differences between the clusters. We also used a single-factor repeated measures ANOVA to examine the variances between the factors in the clusters that were formed. This analysis is suited to examining both the variances

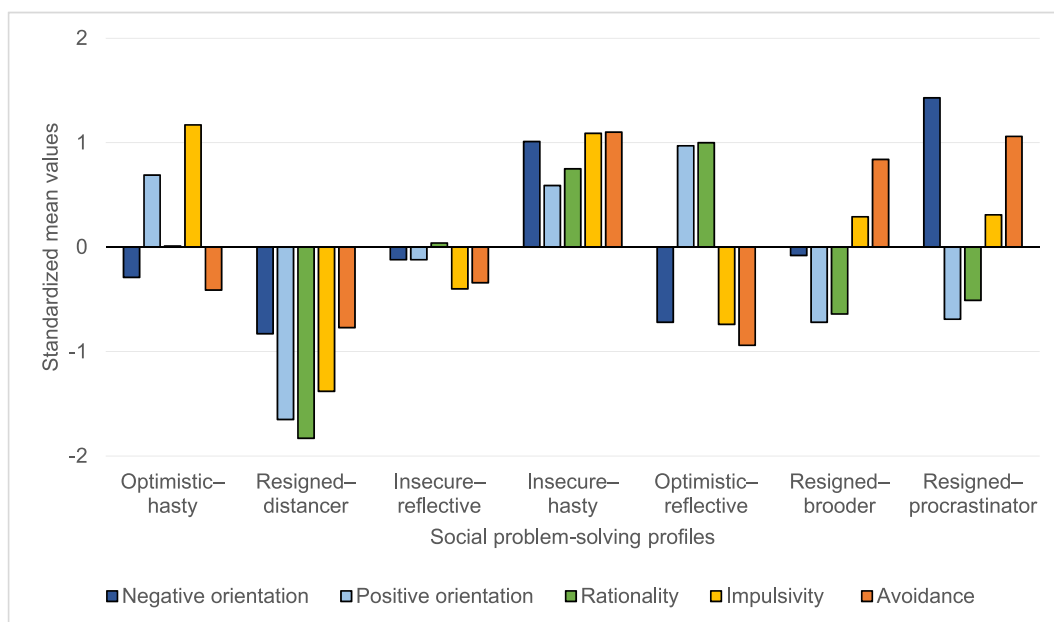


Fig. 1. Social problem-solving profiles among the high school students.

between the factors in the learner profiles and the role of the individual variables. In the case of both variance analyses, we examined whether the variances between the profiles or within them were significant, and whether the weight of the variances was significant in forming the profiles. We checked this based on *F* and partial eta squared and on the related level of significance. In addition, we used a post-analysis ANOVA to examine the variances between and within clusters in both cases. We compared the orientation processes and problem-solving styles to determine the differences between profiles; and we compared the orientation sub-processes and problem-solving styles to determine the differences within profiles. We then named and characterized the profiles based on these statistical analyses. Each profile name consists of two adjectives, the first of which refers to problem-orientation, while the second one refers to the problem-solving style.

To reach the second research aim, we first used ANOVA and the appropriate post-analyses to examine the variances in the relations between the profiles and self-efficacy. We then made a comparison within and between certain learner profiles to analyze the correlation pattern between social problem-solving and self-efficacy.

3. Results

3.1. High school student profiles

During the first step of the study, the students were grouped into four to seven clusters based on the dendrogram (see Appendix A) and agglomeration coefficients produced during the hierarchical cluster analysis. The results of the MANOVA (and the ANOVA to be presented later) reinforce the contention that forming seven clusters is feasible, and that the conditions described in the statistical procedures section could be met. Thus, we decided in favor of the seven-cluster solution which provided the most suitable profiles theoretically and empirically. According to the MANOVA, the differences between clusters in this grouping are significant ($F = 3.15, p < 0.001$; Wilks' $\lambda = 0.03, p < 0.001$; partial $\eta^2 = 0.49$).

The results of the K-mean cluster analysis in the second step can be found in Fig. 1, in which we have provided the means for the standardized values for the social problem-solving scales (*Z* values) by cluster. Table 1 contains the means and standard deviation values as well as the significant differences within certain clusters regarding components of social problem-solving orientation.

Based on the results of both the one-way and the single-factor repeated measures ANOVA, the differences between the means for the seven clusters and within them are significant ($p < 0.001$) regarding the problem-solving scales. Each factor's role is significant in forming the clusters based on the *F* value ($106.79 \leq F \leq 158.48, p < 0.001$) and partial eta squared ($0.55 \leq \eta^2 \leq 0.64$). These values are higher even in the case of the lowest, negative orientation, and the avoidance factor has the greatest weight in forming the learner profiles. The differences between the means for the variables within certain groups are significant in every case ($3.13 \leq F \leq 362.14, p < 0.02$). We distinguished between seven learner profiles based on the results of the cluster analysis: (1) optimistic-hasty, (2) resigned-distancer, (3) insecure-reflective, (4) insecure-hasty, (5) optimistic-reflective, (6) resigned-brooder, and (7) resigned-procrastinator.

3.1.1. Optimistic-hasty

Of the sample, 11% fall into this profile. They characteristically have a high positive orientation, and are impulsive (the variance between these two factors is significant; $p < 0.001$). The means for the other factors are significantly lower ($p < 0.0001$), negative orientation is less common, and the mean for rationality is higher than the mean for avoidance ($p = 0.045$).

3.1.2. Resigned-distancer

In the case of learners in this group, the mean for every factor in 7% of the sample falls below the standardized mean ($Z = 0$). Negative orientation is more common than positive orientation ($p < 0.001$), and avoidance is the most determinant as a problem-solving style, based on whose mean the means for impulsivity and rationality are lower ($p < 0.001$).

Table 1
Features of profiles among the high school students (means for *Z* values, standard deviations, and differences between means).

Factor	Optimistic-hasty (<i>n</i> = 11%)	Resigned-distancer (<i>n</i> = 7%)	Insecure-reflective (<i>n</i> = 23%)	Insecure-hasty (<i>n</i> = 10%)	Optimistic-reflective (<i>n</i> = 21%)	Resigned-brooder (<i>n</i> = 15%)	Resigned-procrastinator (<i>n</i> = 13%)
NO	-0.29 (0.71)	-0.83 (0.69)	-0.12 (0.70)	1.01 (0.85)	-0.72 (0.65)	-0.08 (0.51)	1.43 (0.64)
PO	0.69 (0.65)	-1.65 (0.85)	-0.12 (0.44)	0.59 (0.75)	0.97 (0.64)	-0.72 (0.61)	-0.69 (0.55)
R	0.01 (0.93)	-1.83 (0.67)	0.04 (0.61)	0.75 (0.61)	1.00 (0.64)	-0.64 (0.56)	-0.51 (0.61)
I	1.17 (0.58)	-1.38 (0.65)	-0.40 (0.52)	1.09 (0.71)	-0.74 (0.74)	0.29 (0.69)	0.31 (0.64)
A	-0.41 (0.60)	-0.77 (0.57)	-0.34 (0.52)	1.10 (0.87)	-0.94 (0.50)	0.84 (0.61)	1.06 (0.70)
O	{PO} > {NO}	{NO} > {PO}	{PO} ≈ {NO}	{PO} ≈ {NO}	{PO} > {NO}	{NO} > {PO}	{NO} > {PO}
PSS	{I} > {R} > {A}	{A} > {I} > {R}	{R} > {A, I}	{R} ≈ {I} ≈ {A}	{R} > {I, A}	{A} > {I} > {R}	{A} > {I} > {R}

Note: NO = negative orientation, PO = positive orientation, R = rationality, I = impulsivity, A = avoidance, O = orientation, PSS = problem-solving style; > indicates the direction of the significant difference ($p < 0.05$) obtained during the single-factor repeated measures ANOVA post-analysis; ≈ indicates a non-significant difference.

3.1.3. Insecure–reflective

Of the sample, 23% fall into this group. Typically, negative and positive orientations are both below the standardized mean, with no significant variance between them. Among the problem-solving styles, the mean for rationality is significantly higher than the means for impulsivity and avoidance ($p < 0.001$), with no significant difference existing between the latter two.

3.1.4. Insecure–hasty

Of the sample, 10% fall within this cluster, in which the mean for each factor is above the standardized mean ($Z = 0$). At the same time, there is no significant variance either between the two problem-solving orientations or between the three problem-solving styles, although the mean for positive orientation is significantly lower than the means for impulsivity ($p = 0.01$) and avoidance ($p = 0.034$), thus explaining the significant variance between the individual factors ($F = 3.13, p = 0.02$).

3.1.5. Optimistic–reflective

Learners in this cluster—21% of the sample—are most characterized by a positive orientation and rationality (with no significant variance between the means for the two factors). The means for negative orientation, impulsivity, and avoidance are significantly lower than these factors ($p < 0.001$); they are below the standardized Z value. The only significant variance between them can be found in the case of negative orientation and avoidance ($p = 0.01$), while the means for impulsivity and avoidance do not differ significantly.

3.1.6. Resigned–brooder

Of the sample in our study, 15% fall within this cluster. Like their peers in the *resigned–distancer* group, negative orientation is significantly higher than the mean for positive orientation ($p < 0.001$). The mean for rationality is the lowest among the problem-solving styles in this group as well, with the mean for impulsivity being higher and the mean for avoidance being significantly higher. At the same time, the mean is significantly higher for every factor than those in the *resigned–distancer* cluster ($p < 0.001$).

3.1.7. Resigned–procrastinator

Learners in this cluster (13%) are characterized by a negative orientation and avoidance. The mean for negative orientation is significantly higher ($p = 0.01$) than these factors, and the mean for impulsivity, which is above the standardized mean ($Z = 0$), is significantly lower ($p < 0.001$). The means for rationality and positive orientation (there is no significant difference between these, $p = 0.38$) are significantly ($p < 0.001$) lower than this. This group shows several similarities to the *resigned–brooder* cluster. At the same time, the mean for negative orientation is much higher ($p < 0.001$), while there is no significant variance for the other factors.

We obtain a more nuanced picture of the similarities and differences between the learner profiles if we use an ANOVA post-analysis to examine the difference between the clusters regarding the factors. Since the variances are heterogeneous for each factor ($2.48 \leq \text{Levene's statistic} \leq 4.78, p < 0.02$), we used Dunnett's T3 test. The results can be found in Table 2, where we have provided the significantly distinct groups. The means for the Z values examined in the post-analysis can be found in Table 1.

Based on Table 2, a negative orientation is most characteristic of the *insecure–hasty* and *resigned–procrastinator* profiles, while the mean for this factor is significantly lower ($p < 0.001$) among learners with the *optimistic–hasty*, *insecure–reflective*, and *resigned–brooder* profiles. When compared to these groups, the lowest negative orientation is that of learners in the *resigned–distancer* and *optimistic–reflective* groups, with a positive orientation being more characteristic of the latter group. However, the positive orientation among students with *insecure–hasty* and *optimistic–hasty* profiles is significantly ($p < 0.05$) lower. When compared to these two groups, the mean for positive orientation is significantly lower ($p < 0.001$) in the *insecure–reflective* cluster but higher ($p < 0.001$) when compared to the *resigned–brooder* and *resigned–procrastinator* groups, while it is the lowest among learners with a *resigned–distancer* profile.

The profiles show three key similarities regarding problem-solving styles. The means for the factors are the lowest for the *resigned–distancer* profile, while the means for impulsivity and avoidance are the lowest ($p < 0.001$) for this profile and in the *optimistic–reflective* group. The means for all three problem-solving groups are similar for the *resigned–brooder* and *resigned–procrastinator* profiles; that is, they do not vary significantly, nor do the means for rationality and avoidance vary significantly in the *optimistic–hasty* and *insecure–reflective* groups. The means for rationality are the highest for the *insecure–hasty* and *optimistic–reflective* profiles, and do not differ significantly, while the same holds true for the means for impulsivity for the *optimistic–hasty* and the *insecure–hasty* profiles.

Table 2
Differences between means for profiles by factor among the high school students.

Factor	Significantly distinct profiles
Negative orientation	{RD, OD} < {OH, ID, RB} < {IH, RP}
Positive orientation	{RD} < {RB, RP} < {ID} < {IH, OH} < {OR}
Rationality	{RD} < {RB, RP} < {OH, ID} < {IH, OR}
Impulsivity	{RD} < {OR} < {IR} < {RB, RP} < {IH, OH}
Avoidance	{OR, RD} < {OH, IR} < {RB, RP, IH}

Note: OH = optimistic–hasty; RD = resigned–distancer; IR = insecure–reflective; IH = insecure–hasty; OR = optimistic–reflective; RB = resigned–brooder; RP = resigned–procrastinator; < indicates the direction of the significant difference ($p < 0.05$) obtained during the ANOVA post-analysis (Dunnett's T3 test).

3.1.8. Analysis by self-efficacy profile among the high school students

The relation between self-efficacy and the social problem-solving profiles can be found in Table 3. Based on the findings, the relation between the profiles and self-efficacy varies ($F = 27.86, p < 0.001$), and the differences between the variances are also significant (*Levene's statistic* = 3.44, $p = 0.003$). The composition of the second cluster is mostly heterogeneous, while the other groups are more homogeneous in most cases ($0.37 \leq SD \leq 0.51$). We used Dunnett's T3 test to compare the variances between the means for the clusters.

Based on the social problem-solving orientation processes (positive and negative) (Table 4), learner profiles with a mean for positive orientation that is significantly lower than that for negative orientation (1, 4, and 5) also show a higher self-efficacy than the other clusters, where there is either no significant variance (cluster 3) or the mean for negative orientation is significantly higher. In the clusters where the means for rationality and impulsivity are high (1, 4, and 5), the mean for self-efficacy is also significantly higher than in the other groups. In contrast, in the groups where the mean for avoidance is significantly higher when compared to other styles (2, 6, and 7), the level of self-efficacy is significantly lower.

We obtain a more nuanced picture of the relationship between self-efficacy and social problem-solving if we examine the correlation pattern regarding the learner profiles. We first interpreted the results for the entire sample and then based on the learner profiles. The relations were significant for the entire sample on every scale. The correlation was significant for both the positive orientation ($r = 0.59, p < 0.001$) and the negative orientation ($r = -0.32, p < 0.001$). At the same time, the coefficient rate varies due to the differing orientation. Among the problem-solving styles, the relation between rationality and self-efficacy is the closest ($r = 0.46, p < 0.001$), the link to impulsivity is weak ($r = 0.12, p = 0.01$), and avoidance shows a negative significant relation with self-efficacy ($r = -0.22, p < 0.001$). Based on the learner profiles, we observed a trend regarding the orientation processes that is similar to that for the entire sample, although—presumably due to the smaller sample—the correlation coefficient is frequently non-significant. However, among the problem-solving styles, only impulsivity had a significant relation with self-efficacy among learners in the *resigned-distancer* ($r = 0.49, p = 0.03$) and *resigned-brooder* ($r = 0.39, p < 0.01$) clusters.

3.2. University student profiles

Based on the dendrogram (see Appendix B) and agglomeration coefficients formed based on the hierarchical cluster analysis conducted during the first phase of the analysis, the individuals under examination can be grouped into four to six clusters based on several different arrangements. Based on the MANOVA results, we identified significant variances between the clusters when they are broken down into six groups ($F = 1.87, p < 0.001$, Wilks' $\lambda = 0.05, p < 0.001$, partial $\eta^2 = 0.46$). We thus decided on this grouping.

Fig. 2 shows the results from the K-means cluster analysis in the second phase, while Table 4 contains the means and standard deviations for the Z values by student profile as well as the significant differences between the orientation process and problem-solving style factors within the individual clusters.

The differences between the means for the six clusters and within them are significant ($p < 0.001$) based on the results of one-way and single-factor repeated measures ANOVA regarding the problem-solving scales. Each factor plays a significant role in forming the clusters based on the F values ($48.86 \leq F \leq 89.80, p < 0.001$) and the partial eta squared ($0.47 \leq \eta^2 \leq 0.62$). The values are high even in the factor with the lowest value, which is impulsivity. The rationality factor has the greatest weight in forming the profiles. We identified significant differences ($6.66 \leq F \leq 139.17, p < 0.001$) between the means for the variables within the individual groups in every case. Six student profiles took shape based on the cluster analysis: (1) optimistic-modest, (2) tense-hasty, (3) optimistic-hasty, (4) optimistic-reflective, (5) tense-reflective, and (6) resigned-procrastinator.

3.2.1. Optimistic-modest

Of the sample, 19% fall within this cluster, in which the mean for every factor is below the standardized mean. Positive orientation is significantly higher than the mean for negative orientation ($p < 0.001$). There is no significant variance between the means for the problem-solving styles.

Table 3
Means and standard deviations for self-efficacy by profile among the high school students.

Cluster	n (%)	Self-efficacy		Differences between means
		M	SD	
1. Optimistic-hasty	14	3.27	0.38	{1, 4, 5} > {3, 6} > {2, 7}
2. Resigned-distancer	7	2.48	0.83	
3. Insecure-reflective	3	2.95	0.37	
4. Insecure-hasty	13	3.24	0.51	
5. Optimistic-reflective	28	3.37	0.41	
6. Resigned-brooder	17	2.86	0.46	
7. Resigned-procrastinator	18	2.54	0.43	

Note: The numbers for the clusters can be found in the column comparing the inter-group differences; > indicates the direction of the significant difference ($p < 0.05$).

Table 4

Features of profiles among the university students (means for Z values, standard deviations, and differences between means).

Factor	Optimistic–modest (n = 19%)	Tense–hasty (n = 19%)	Optimistic–hasty (n = 21%)	Optimistic–reflective (n = 18%)	Tense–reflective (n = 18%)	Resigned–procrastinator (n = 5%)
NO	−0.87 (0.54)	0.78 (0.59)	−0.03 (0.66)	−0.75 (0.58)	0.36 (0.90)	2.07 (0.48)
PO	−0.31 (0.80)	−0.70 (0.58)	0.61 (0.66)	1.00 (0.52)	−0.13 (0.80)	−1.97 (0.76)
R	−0.75 (0.69)	−0.75 (0.70)	0.05 (0.56)	0.97 (0.55)	0.97 (0.54)	−1.26 (0.82)
I	−0.34 (0.71)	0.75 (0.73)	0.73 (0.61)	−0.56 (0.83)	−0.94 (0.68)	0.58 (1.12)
A	−0.53 (0.63)	0.91 (0.68)	−0.17 (0.61)	−0.85 (0.46)	0.16 (0.97)	2,07 (0.67)
O	{PO} > {NO}	{NO} > {PO}	{PO} > {NO}	{PO} > {NO}	{NO} > {PO}	{NO} > {PO}
PSS	{I} ≈ {A} ≈ {R}	{A, I} > {R}	{I} > {R, A}	{R} > {I, A}	{R} > {A} > {I}	{A} > {I} > {R}

Note: NO = negative orientation, PO = positive orientation, R = rationality, I = impulsivity, A = avoidance, O = orientation, PSS = problem-solving style; > indicates the direction of the significant difference ($p < 0.05$) obtained during the single-factor repeated measures ANOVA post-analysis; ≈ indicates a non-significant variance.

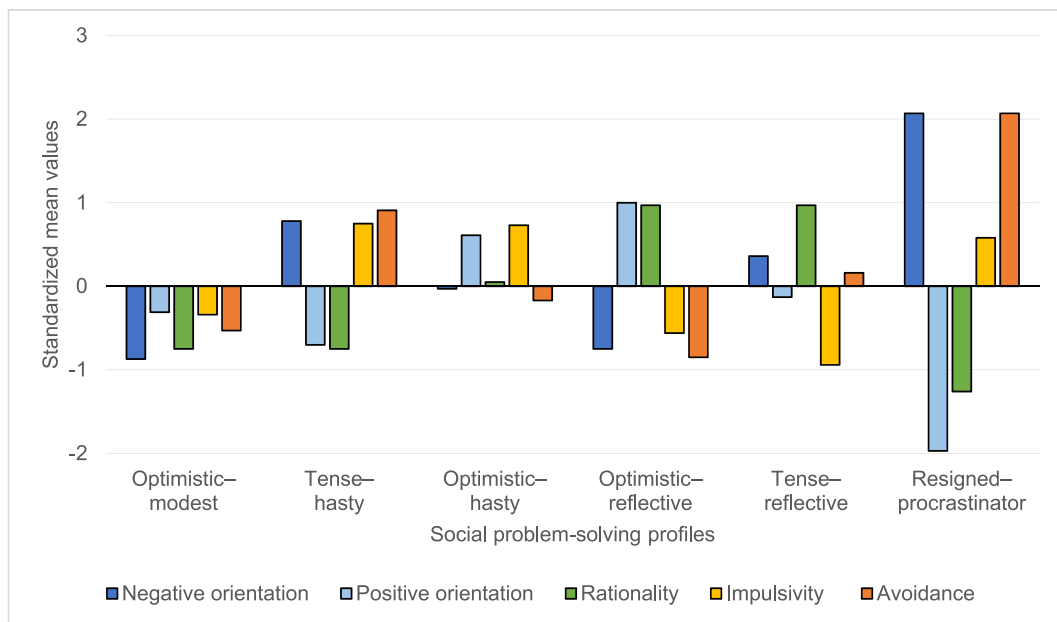


Fig. 2. Social problem-solving profiles among the university students.

3.2.2. Tense–hasty

Of the sample, 19% fall within this cluster, which is characterized by a high negative orientation, impulsivity, and avoidance (with no significant variance between these factors). The means for positive orientation and rationality, between which there is no significant difference, are significantly lower ($p < 0.001$) than these factors in every case.

3.2.3. Optimistic–hasty

Of the sample, 21% are grouped into this cluster, in which the means for positive orientation and impulsivity are high (with no significant variance between them). The means for negative orientation, rationality, and avoidance, which do not differ significantly, are significantly lower ($p < 0.001$) when compared to these factors.

3.2.4. Optimistic–reflective

Of the students, 18% are grouped into this cluster, in which—in contrast to the members of profile 2 (tense–unorganized)—a positive orientation and rationality are more common. There is no significant variance between the means for these factors, and they are significantly higher ($p < 0.001$) when compared to the negative orientation, impulsivity, and avoidance scales, the means for which do not vary significantly.

3.2.5. Tense–reflective

The students within this cluster (18%) are characterized by a negative orientation and rationality, from among which the mean for rationality is significantly higher ($p = 0.01$). The mean for avoidance is significantly lower ($p < 0.001$) than the mean for rationality and above the standardized mean ($Z = 0$); the mean for impulsivity is significantly lower ($p < 0.001$) than that for avoidance.

3.2.6. Resigned–procrastinator

The students placed into this cluster (5%) greatly resemble those in the *tense–hasty* cluster. At the same time, this group has the highest means for negative orientation and avoidance (between which there is no significant variance); the mean for impulsivity is also significantly lower ($p < 0.001$) than the means for these other factors.

We used Dunnett’s T3 test for negative orientation and avoidance due to the significant differences ($3.23 \leq \text{Levene’s statistic} \leq 4.92$, $p < 0.01$) between the variances from among the ANOVA post-analyses to examine the similarities and differences between the clusters. We used Tukey’s B test for the other factors, because there were no significant differences between the variances. Table 5 contains the variances between the means for the student profiles (cf. Table 4) regarding the individual factors based on these post-analyses.

Based on the problem-solving orientation processes, a negative orientation is more common in the *resigned–procrastinator* group, while the mean for negative orientation in the *tense–hasty* profile is significantly lower ($p < 0.001$). When compared to this group, the mean for negative orientation is lower ($p < 0.01$) for the *optimistic–hasty* and *tense–reflective* student profiles; at the same time, the means for these groups are higher ($p < 0.001$) when compared to those for the *optimistic–modest* and *optimistic–reflective* groups. Clearly, the means for positive orientation are the opposite of this order, except for the *optimistic–modest* profile, where positive and negative orientation both fall under the standardized Z value ($Z = 0$).

We identified several different similarities in the profiles regarding the problem-solving styles. The means for rationality were regularly higher ($p < 0.001$) for the student profiles characterized by optimism and reflection when compared to those with tense and anxious characteristics. The means for impulsivity in the *optimistic–hasty*, *tense–hasty*, and *resigned–procrastinator* groups were higher ($p < 0.05$) than for the other profiles. Avoidance was most common among those with the *resigned–procrastinator* profile; the means for avoidance were lower ($p < 0.001$) in the *tense–hasty*, *tense–reflective*, and *optimistic–hasty* groups, while this problem-solving style was the least characteristic of the *optimistic–reflective* and *optimistic–modest* student profiles.

3.2.7. Analysis by self-efficacy profile among the university students

Regarding the second research aim, we examined the means for self-efficacy in the university subsample and the variances between them via the profiles formed (Table 6). The difference between the means was also significant in this subsample ($F = 10.10$, $p < 0.001$), which is consistent with the findings of the study among the adolescents. As there was no significant difference between the variances ($\text{Levene’s statistic} = 1.33$, $p = 0.26$), we compared the clusters based on Tukey’s B test.

However, the self-efficacy level was significantly higher in profiles where the mean for positive orientation was higher than that for negative orientation, and rationality was more common (profiles 1, 3, and 4). In profiles where the means for negative orientation, avoidance, and impulsivity were higher (1 and 6), self-efficacy was lower. Self-efficacy was average in the *tense–hasty* and *tense–reflective* student profiles (cf. Table 6). Negative orientation is more common for these profiles, avoidance and impulsivity are characteristic of the *tense–hasty* profile, and rationality is typical of the *tense–reflective* profile (cf. Table 4).

Similar to the high school sample, we found a significant relation with self-efficacy regarding the social problem-solving scales among the university students as well—except for impulsivity. The correlation coefficients were significant both for positive orientation ($r = 0.56$, $p < 0.001$) and negative orientation ($r = -0.64$, $p < 0.001$), but their direction differed. From among the problem-solving styles, the relation between rationality and self-efficacy was significant ($r = 0.29$, $p = 0.003$), while a negative significant relation was also identified in this subsample for avoidance ($r = -0.38$, $p < 0.001$).

Examining the correlation pattern by cluster, we found that self-efficacy relates significantly to positive orientation ($r = 0.46$, $p < 0.05$) and to impulsivity ($r = -0.50$, $p < 0.05$) for the *optimistic–reflective* group, but their direction differs. The relation between negative orientation and self-efficacy is significant in the negative direction ($r = -0.72$, $p < 0.001$) in the *tense–reflective* cluster. In the case of the other groups—presumably due to the lower sample size—there is no significant correlation between self-efficacy and problem-solving.

4. Discussion

The present investigation sought to identify profiles using a person-centered approach to provide a deeper understanding of social problem-solving, as it appears to be suitable for examining this process. Interestingly, despite models of social problem-solving stating that its components are likely to occur in some combinations (e.g. Refs. [1,3,4]), these combinations have not been directly examined.

Table 5
Differences between means for profiles by factor among the university students.

Factors	Significantly distinct profiles
Negative orientation	{OM, OR} < {OH, TR} < {TH} < {RP}
Positive orientation	{RP} < {TH, TH} < {TR} < {OH, OR}
Rationality	{RP} < {OM, TH} < {OH} < {OR, TR}
Impulsivity	{TR, OR} < {OM} < {RP, OH, TH}
Avoidance	{OR, OM} < {OH, TR} < {TH} < {RP}

Note: OM = optimistic–modest; TH = tense–hasty; OH = optimistic–hasty; OR = optimistic–reflective; TR = tense–reflective; RP = resigned–procrastinator; < indicates the direction of the significant difference ($p < 0.05$) obtained from the ANOVA post-analysis.

Table 6
Means and standard deviations for self-efficacy by profile among the university students.

Cluster	n (%)	M	SD	Differences between means
1. Optimistic–modest	10	3.06	0.55	{4} > {5, 2} > {6},
2. Tense–hasty	25	2.75	0.48	{1, 3} > {6}
3. Optimistic–hasty	22	3.08	0.37	
4. Optimistic–reflective	19	3.43	0.41	
5. Tense–reflective	20	2.89	0.41	
6. Resigned–procrastinator	5	2.12	0.22	

Note: The numbers for the clusters can be found in the column comparing the inter-group differences; > indicates the direction of the significant difference ($p < 0.05$).

The results support the existence of three homogeneous profiles with shared characteristics in the two age groups under investigation. These include the following: optimistic–hasty, optimistic–reflective, resigned–procrastinator. Members of the optimistic–hasty group are characterized by both rationality and impulsivity: they believe they can solve a specific problem, and try to consider several solutions to it; however, they tend to make quick decisions, their behavior is less reflective but rather hurried. The optimistic–reflective group is characterized by the highest level of rationality: members of this group carefully consider the problem itself, the possible solutions, and the potential positive and negative consequences as well. They make unhurried decisions, and act calmly. Members of the resigned–procrastinator group demonstrate low self-efficacy, they do not believe in themselves, they are insecure about their decision-making situation. They prefer to avoid handling difficult situations, and they postpone dealing with problems.

In addition, we identified four other groups among high school students (resigned–distancer, insecure–reflective, insecure–hasty, and resigned–brooder). All four share insecurity, worrying, and anxiety in facing social problems; however, while those in the *insecure–reflective* group basically believe in the success of their decisions, members of the *resigned–distancer* and the *resigned–brooder* groups do not want to face problems, and would rather avoid decision-making situations. The avoidance factor identified in the high school sample has the most weight in forming the learner profiles, thus reinforcing the findings from previous studies (e.g. Ref. [2]): the degree of avoidance is significantly higher among 13–15-year-olds when compared to those in the pre-puberty years. Many adolescents tend not to solve problems or postpone doing so, with the aim possibly being complete, long-term neglect or postponement for the purpose of gathering strength for later problem-solving.

Besides the four groups noted among the adolescents, we identified three further groups among university students. Members of the *optimistic–modest* group face problems head on, and carefully consider possible solutions and their positive and negative consequences with a clear aim in mind. Members of the *tense–reflective* group handle problem situations well, consider the positive and negative consequences of possible solutions, their decisions are less influenced by emotions. In both cases, the partial eta squared value was highest for rationality, so this problem-solving style decisively determined the formation of this cluster. Members of the *tense–hasty* group have quite similar characteristics to those of the *resigned–procrastinator* group; however, their problem-solving style is rather determined by impulsivity.

We also examined the difference that individual homogeneous groups exhibit in their subjective assessment of self-efficacy. According to our results, groups formed based on social problem-solving factors show significant differences regarding self-efficacy and certain factors in both age groups under examination. In profiles among the high school and university students, where the mean for positive orientation was significantly higher than the mean for negative orientation (optimistic–hasty, optimistic–reflective), the mean for self-efficacy is significantly higher. The relation between self-efficacy and rationality can also be demonstrated in both age groups. These findings reinforce the existence of relations found in earlier studies ([32,33]). At the same time, studying self-efficacy according to profiles also shows that there are patterns of social problem-solving factors, in which self-efficacy is tied to avoidance and impulsivity. In both age groups, in learner groups in which the mean for avoidance was significantly higher than the means for other styles (resigned–distancer, resigned–brooder, and resigned–procrastinator), the level of self-efficacy was lower. It can thus be assumed that those who have less of a belief that they can solve their problems more frequently choose to avoid solving the problem. In addition, the stronger presence of impulsivity among high school students is also tied to a lower self-efficacy in a few profiles (resigned–distancer and resigned–brooder).

5. Limitations

The present study makes some significant contributions to the literature in the field of social problem-solving research. This investigation has shown the added value of the person-centered approach by identifying distinct subgroups of participants regarding their social problem-solving. Identifying these subgroups would not have been possible when using variable-centered approaches. Another contribution of this approach is that it becomes visible that the relations between social problem-solving factors and self-efficacy can differ significantly within subgroups. The highly similar profiles across the two age groups suggest that the four profiles that have been identified are not unique patterns.

However, some limitations in the present investigation should be noted. Most of these concern the sample of the study, while others are related to the methodology we used. We used convenience sampling, which may distort the sample in both groups, especially in the young adult group. This is, firstly, because the sample only consisted of students at an institute of higher education. Secondly, the socioeconomic status of university students is typically average or above (cf [56]), and, according to our previous study, socioeconomic background plays an important role in the development of social problem-solving [49]. Third, the students were mainly

pre-service teachers, and it is possible that certain individual character traits that influence problem-solving and self-efficacy are more common among these students. Fourth, the present research involved Hungarian adolescents and young adults, which may influence the generalizability of our findings (e.g. Refs. [20,57,58]). Lastly, the sample of university students was smaller than that of secondary school students, which may have a role in the variations of social-problem solving profiles.

From a methodological point of view, it is important to note that the participants were asked to assess situations tied to their peers via the SPSP-R, which was used to measure social problem-solving. Since problem-solving style becomes increasingly context- and person-specific (cf [3]), it is possible that profiles identifiable based on internal correlations between the constituents of problem-solving and the scales would have differed from the findings of the current study. This is very likely, because our previous studies [2] have shown that with adolescents, impulsivity is more significant in problem-solving tied to parents (parent-child problem-solving), while they prefer avoidance when teachers are involved, a finding that is also reinforced by classroom observations [19]. The data collection was based on self-reporting, which increases distortion due to social desirability. An additional potential weakness of the applied cluster analysis method is tied to decision-making related to the optimal number of profiles, in which—although it is based on a consideration of statistical results—researchers' considerations also play a role.

6. Future research directions

Due to the limitations we have noted, it will be necessary in the future to check the presence of profiles in the university age group by including young adults with below-average socioeconomic status in a heterogeneous sample. There are also cultural differences in the operation and development of social problem-solving (e.g. Refs. [20,57,58]), so it is worth checking the profiles and correlations that have been found in future comparative investigations.

It would be interesting to examine profiles that have come about based on further sources of data and the relations between the profiles and self-efficacy. A longitudinal research design may significantly contribute to a more detailed examination of these relations and an understanding of their causal connections. An examination of differences by profile of correlates (e.g., anxiety and procrastination) that take shape based on previous studies using a variable-centered approach may provide further reinforcement regarding the significance of the profiles identified in the present research. Several other methods can be used to form profiles in the person-centered approach (cf [37,38]); in the future, it is worth examining potential profiles with other methods suited to studying social problem-solving.

7. Conclusion

In sum, this study found three profiles of social problem-solving among Hungarian adolescents and young adults that are similar in both age groups. Furthermore, the present results showed that these profiles had unique patterns of association with self-efficacy. The findings highlight the importance of taking the interplay of the factors of social problem-solving into account to better understand one's characteristics related to social problem-solving. These results also contribute to the research literature on the potential benefits of enlisting a person-centered approach in exploring individual differences in social problem-solving. The profiles identified can help in designing targeted school development programs, and if further research reveals similar profiles, it may be possible to formulate general development aims along these lines.

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Ethics statement

The study was approved by the United Ethical Review Committee for Research in Psychology (EPKEB) in Hungary (permit No. 2017/125).

Author contribution statement

József Balázs Fejes: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.
Szilvia Jámbori: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

László Kasik: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Tibor Vigh: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Zita Gál: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e18913>.

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