



Full length article

Playing styles based on experiential learning theory

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ABSTRACT

In recent years, researchers have reported positive outcomes and effects from applying computer games to the educational process. The preconditions for an effective game-based learning process include the presence of high learning interest and the desire to study hard. Therefore, educational video game design has to tailor gameplay to the style of the playing learner, i.e. to the psycho-cognitive abilities, attitudes, and skills of the individual player, in order to foster the player's motivation and creativity. To achieve this goal, it is necessary to draw a parallel between learning styles and styles of playing video games, and to investigate the correlations between these types of constructs. The article presents a new family of playing styles based on Kolb's experiential learning theory that is appropriate to be used for educational video games. This family is composed of four playing styles: Competitor, Dreamer, Logician, and Strategist, and corresponds to Honey and Mumford's learning styles based also on the theory of experiential learning, namely Activist, Reflector, Theorist, and Pragmatist. To measure the four playing styles, a 40-item questionnaire was designed. In order to verify the consistency, validity, and reliability of that questionnaire as an accurate tool for recognizing the four suggested player styles, a pilot study was conducted. The article reports the results obtained from the study, along with their analysis and applicability.

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1. Introduction

Digital games are becoming increasingly popular in our daily life and are recognized not only as a means of entertainment but also as a highly interactive and challenging medium for learning and training. Therefore, it has become an important task to estimate whether correlations between learning and playing styles do exist. Prensky (2001) identified 12 structural game elements including goal, problem solving, outcomes and feedback, interactivity, and adaptivity. All of them are crucial for modern game-based educational practices which foster motivation, flow, and creativity among learners (Bateman, Lowenhaupt, & Nacke, 2011). Hence, they would enhance the overall educational playability of serious games applied for education and training (Brisson et al., 2012). For this purpose, modern video games should be aligned with the cognitive style of individual learners (Sternberg & Grigorenko, 1997),

reflecting their needs and preferences in the context of learning and/or playing.

Traditionally, learning and playing styles are discussed and applied separately in video games. Learning styles refer to the ways in which a student prefers to assimilate and process information (Tsingos, Bosnic-Anticevich, & Smith, 2015). On the other hand, playing style is determined generally by the typical behavior of the player during the game. Hence, playing styles define human personality in the context of structured, challenge-based playing a game (Stewart, 2011) but not of potentially challenge-free playing with a toy. In order to classify playing styles, different approaches have been experimented based on various concepts, such as:

- the player's associations with the game environment and relationships with other players (Bartle, 1996);
- human-computer interactions, like exploring the game world (Klawe, 1999) or speed of play (Heeter & Winn, 2008);
- the psychological profile of the player (Bateman & Boon, 2005; Nacke, Bateman, & Mandryk, 2013);

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- personal characteristics in the context of playing, such as the intrinsic and extrinsic motivations of the players (Magerko, Heeter, Fitzgerald, & Medler, 2008);
- preferences for game genres such as fighters, puzzle games, simulations, adventure games, etc. (Kirriemuir & McFarlane, 2004) and for gaming experience (Ventura, Shute, & Kim, 2012).

The goal of any game is to attract and entertain the player. However, this is difficult to achieve because different people search for different things from a game and have different reasons for liking it or not. Therefore, it is very important to calculate and classify playing styles using accurate tools, for both entertainment and serious games. For games applied for educational purposes, playing style should be aligned with the learning process of experimentation and knowledge acquisition in the game. Aleksieva-Petrova, Petrov, and Bontchev (2011) proposed a family of game playing styles named after the ADOPTA (Adaptive technology-enhanced platform for edutainment) project and based on Kolb's experiential learning theory (Kolb, 1984). The authors considered four game playing styles (Competitor, Dreamer, Logician, and Strategist) focused on individual gameplay preferences. They applied these game playing styles along with the learning styles of Honey and Mumford (1992) for tailoring the learning process to individual needs and preferences.

The present study aims to identify specific features of the four ADOPTA game playing styles in the context of playing digital games applied for education and training. It proposes a questionnaire for measuring these playing styles reflecting their key features. Moreover, the current article presents a pilot study administering a joint questionnaire about previous gaming experience and both the ADOPTA playing styles and Honey and Mumford's learning styles. Quality characteristics of the playing style questionnaire are analyzed and reported, including its internal consistency, concurrent validity, and reliability. Results of the conducted analysis found that the developed questionnaire has acceptable internal consistency and good concurrent validity and reliability.

2. Background

2.1. Learning styles

Learning styles were defined by Curry (1981) as “characteristic cognitive, affective, and psychosocial behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment”. Some researches examine the relevant neuroscientific and educational evidence in the light of the brain's interconnectivity includes the senses, especially vision and hearing (Geake, 2008). Jackson (2002) proposed four learning styles based on neuropsychology of personality: initiator, reasoner, analyst and implementer. Those learning styles are influenced to varying degrees by biology as well as by experience and conscious control.

Based on the transformation of experience, Kolb (1984) defined his Learning Style Inventory (LSI) with learning styles organized in a two-dimensional space, where the abscise axis represents the Processing Continuum (how a person approaches a task – observing or doing it) and the ordinate axis Perception Continuum (how he/she thinks or feels about a task, i.e. his/her emotional response). Honey and Mumford (1992) developed their learning styles model based on Kolb's work but using a different approach. They officially coined the reflector/pragmatist and theorist/activist styles as mutually corresponding while the Kolb model (Kolb & Kolb, 2005) defines learning styles as a product of combinations of the learning cycle stages. Thus, the learning styles of Honey and Mumford (presented in the peripheral circles in Fig. 1) can be

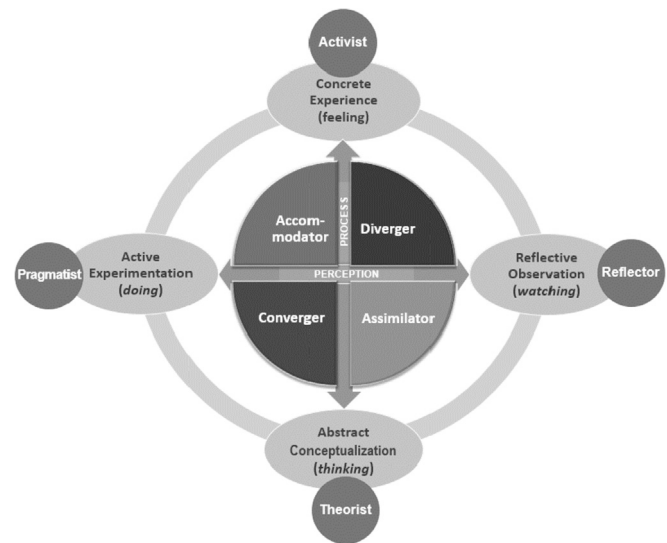


Fig. 1. Relationship between learning styles based on LSI.

described as follows:

1. Activist learning style characterizes people who are usually open to new ideas and like to try new things. Their main activities are brainstorming, problem solving, group discussion, puzzles, competitions, and role-play.
2. Theorist style is typical of those who think logically and assimilate all the facts systematically into the problem (coherent theories). Their main activities comprise the exploration of models, statistics, stories, background information, applying theories, and so on.
3. Reflectors like to stay at a distance and consider the situation from different perspectives. Some of their activities include paired discussions, self-analysis questionnaires, personality questionnaires, time out, observing activities, feedback from others, interviews.
4. Pragmatists are willing to try things and want concepts that can be applied to their work. They need to be able to seek out new ideas and take the opportunity to try them out in the real world as soon as possible.

The Learning Styles Questionnaire (LSQ) was designed by Honey and Mumford (1992) and was initially designed with 80 dichotomous items in four groups of 20 items for each of the four learning styles. The 80-item LSQ was widely used worldwide for finding preferences of learning style in both industry and academia because of its good test-retest reliability (Honey and Mumford (1992)) and acceptable internal reliability (Cockerton, Naz, & Sheppard, 2002), though no evidence was reported about both its construct and predictive validity. Honey and Mumford (2000) suggested a shorter, 40-item version of their LSQ specially designed for online surveys. Many subsequent studies validated the applicability of experiential learning theory and established supportive mechanisms and methods of ‘learning by doing’ in education practice worldwide (Penger, 2009).

2.2. Playing styles

2.2.1. The essence of playing style

Historically, the creation of player typologies progressed in parallel with development models of games. Stewart (2011) claimed player types appear to be functional models of “human

personality in a game playing context” and should be considered together with game design models. Indeed, both player personality and game models concern the nature of the process of play. The first typology of playing behavior was suggested by [Caillois and Barash \(1961\)](#) including four different forms of play: *Agon* (games of competition), *Alea* (games of chance), *Mimicry* (role-playing games), and *Ilinx* (games provoking vertigo and other effects reshaping the player's perception) – all considered as patterns of play. [Magerko et al. \(2008\)](#) distinguished playing types (defined as persistent traits of the player) from playing styles treating “motivations as a more temporary state, with an implication that players may adopt different play styles in different games or at different times”. Therefore, the playing style of an individual is to be defined in the context of a given game type and for a particular period of time. Both playing types and styles are crucially important for player-centric adaptation of digital games ([Bontchev & Georgieva, 2017](#)).

2.2.2. Playing style families

First, Richard [Bartle \(1996\)](#) proposed a family of player types based on long-term observations and analyses of player behavior in massively multiplayer online (MMO) adventure video games. The Bartle types are four: Killers, Achievers, Explorers, and Socializers. While Bartle suggested his four player types mainly in the context of MMO games, other researchers did so in the context of serious games for education. [Klawe \(1999\)](#) found two other playing types adopted by children while playing an educational video game. While some children pursued a fast win, others preferred to explore the game world. In another educational game, [Heeter and Winn \(2008\)](#) differentiated playing styles based on the speed of play and the success in problem solving. The authors found that rewards given during the game can either hamper or facilitate learning outcomes, depending on the playing style of the individual.

Many player typologies were developed based on either psychological typologies ([Bateman & Boon, 2005](#)) or psychological trait theories ([Bateman et al., 2011](#); [Nacke et al., 2013](#)). The demographic game design (DGD1) player typology was proposed by [Bateman and Boon \(2005\)](#) as a derivation from the Myers-Briggs Type Indicator and the Jung Temperament theory. DGD1 involved four categories of player types and gameplay preferences: conquerors, managers, wanderers, and participants. After DGD1, the DGD2 player model was conceived based on the Temperament theory; it contains logistical, tactical, strategic, and diplomatic player types ([Bateman et al., 2011](#)). DGD1 and DGD2 were inherited by the BrainHex model, which was suggested by [Nacke et al. \(2013\)](#) and contains archetypes of a particular player experience, such as seekers, survivors, daredevils, masterminds, conquerors, socializers, and achievers.

While discussing playing style, [Magerko et al. \(2008\)](#) treated motivation as “a central correlate to learning” introducing a parallel between playing and learning styles. Within the scope of the ADOPTA project, [Aleksieva-Petrova et al. \(2011\)](#) outlined a family of styles of playing video games based on Kolb's experiential learning theory. The ADOPTA family has four game playing styles – Competitor, Dreamer, Logician, and Strategist ([Fig. 1](#)), focused on individual gameplay preferences. The authors applied these playing styles to control the flow of educational game decision points for achieving a runtime adaptation of courseware delivery.

The Jung Temperament theory has been used as a base for establishing a mapping between existing game player models and playing styles ([Bateman et al., 2011](#); [Cowley & Charles, 2016](#); [Stewart, 2011](#)). Similarly to these approaches, we can compare the playing styles of Bartle, Bateman and Boon, and of Aleksieva-Petrova et al. according to their characteristics, as shown in [Table 1](#). In addition, a parallel with the learning styles of Honey and

Mumford is also drawn, insofar as both they and the ADOPTA playing styles are defined on top of Kolb's theory of experiential learning.

3. ADOPTA playing style questionnaire

For developing a playing style-based questionnaire similar to the popular Honey and Mumford's dichotomous 40-item LSQ, we defined each playing style (Competitor, Dreamer, Logician, and Strategist) in a more precise way, as below. For each style, we identified (together with a panel of experts in the field) 10 questions relative to key gameplay preferences typical for the style. Our choice to make the response options dichotomous was determined only by the goal to facilitate a direct comparison of the results to these of the Honey and Mumford's 40-item LSQ. The ADOPTA playing style-based questionnaire (ADOPTA PSQ) is provided in an [Appendix](#) at the end of the article.

3.1. Competitor

Competitors (corresponding to the Activist learning style of Honey and Mumford) are players who enjoy action and shooting and are focused on the competition itself. This playing style uses not only shooting but also various instruments found in other types of games. It supposes good hand–eye coordination, the ability to take great risks that seem to them reasonable and, in addition, quick thinking when planning and choosing tactics in gameplay. Competitors are intuitive, open-minded and have strong feelings; they rely mostly on their intuition rather than theoretical analysis and find spontaneous actions and strong competition to be the best opportunities for discovering new things and ideas, improving themselves and, eventually, winning the game. The relevant question numbers are 1, 5, 9, 13, 17, 22, 26, 30, 34, and 38.

3.2. Dreamer

Dreamer (corresponds to Reflector) represents a style of players who like playing roles and thrive in the fantasy world of avatars where they prefer to observe the gameplay rather than control it. They like guided gameplay and staying at a given game level until they have mastered it sufficiently. Dreamers need to gather different perspectives about game missions and to consider them carefully before they start playing actively. Dreamers demonstrate good communication and collaborative skills while being open-hearted about their feelings. They prefer to observe and listen to the arguments of others before making decisions and communicating them. Dreamers are fond of social interaction, diplomacy, and negotiation. They like diving into complex gameplay situations as well as playing through clear game scenarios instead of emergent gameplay. The relevant question numbers are 2, 6, 10, 14, 18, 23, 27, 31, 35, and 39.

3.3. Logician

Naturally, Logicians (correspond to Theorists) enjoy logic, analyses and pattern-based approaches for executing any task in a game, and possess good spatial awareness and contextual thinking, together with verbal skills, as well as numeracy and spelling skills. They learn the intricacies of each game rule in order to apply them to each move in a rational and perfect way. They like exploring the game space and assimilating all the gameplay facts in a stepwise, detailed and precise way. They like to be recognized by the other players as being rational, methodical, and objective. The relevant question numbers are 3, 7, 11, 15, 19, 24, 28, 32, 36, and 40.

Table 1
Relationships between Bartle, DGD2, and ADOPTA playing styles, with a parallel with Honey and Mumford learning styles – built upon (Stewart, 2011), (Bateman et al., 2011), and (Cowley & Charles, 2016).

Drawn to/Recognized as/Tolerant of	Motivation/ Problem/ Overall goal	Bartle	DGD2	ADOPTA	Honey and Mumford	Learns by
improvisation, operation, controlling single characters, thinking on the spot/impulsive, competent/risk, speed, variation	power/ performance/ do	Killer	Tactical	Competitor	Activist	hand–eye coordination, planning tactics and fast problem-solving, team working
problem solving, hypothesizing, controlling multiple units, thinking ahead/logical, perfect/complexity	knowledge/ perception/ know	Explorer	Strategic	Logician	Theorist	entering problems gradually, with spatial awareness and verbal/mathematical skills
optimization, planning, control/cautious, meticulous/repetition, rules, procedures	security/ persistence/ have	Achiever	Logistical	Strategist	Pragmatist	planning and decision-making in management tasks, proving hypotheses requiring strategic thinking
harmonizing, imagining, cooperation/empathic, moral/impressionism	identity/ persuasion/ become	Socializer	Diplomatic	Dreamer	Reflector	observing and watching reflectively, listening to the others

3.4. Strategist

Strategist (corresponds to the Pragmatist learning style) is a player who likes resolving complex problems within a game in the most effective way. Such players do not like acting/shooting without reasonable expectations of good results and benefits in the game and try to find practical ways to fulfill the game tasks on time. They demonstrate long-term thinking when planning their strategies and like decision-making, testing hypotheses, and seeing the practical consequences of their experiments and actions taken. Strategists like anything, which works. The relevant question numbers are 4, 8, 12, 16, 20, 25, 29, 33, 37, and 41.

For each of the four styles, we selected 10 typical key characteristics and built upon them 10 dichotomous (Yes-No) questions. We preferred to use a dichotomous scale rather than the Likert scale, just to be able to correlate more easily the ADOPTA playing styles with the correspondent learning styles of Honey and Mumford. Hence, we defined a playing style questionnaire consisting of 40 dichotomous questions divided into four groups of 10 questions each, corresponding to the four playing styles (Competitor, Dreamer, Logician and Strategist). All the questions were shuffled in order not to bore respondents with the same concept and to attract their attention to different aspects of gameplay.

4. Pilot study

A pilot study was conducted to try out ADOPTA PSQ as a research tool. The study aimed at providing an initial examination of the questionnaire's validity and reliability and, next, at introducing possible modifications of items according to factor analysis results before doing a large-scale study. For the sake of realism, we preferred an undeclared pilot mode instead of a participatory pilot. The pilot was planned to have PSQ administered to a smaller sample of respondents, which should be sufficient to perform factor analysis. Hatcher (1994) recommended that the number of subjects should be at least five times greater than the number of variables. Therefore, we planned to administer our 40-item PSQ to no less than 200 respondents.

4.1. Instruments

In order to explore the concurrent validity of PSQ, we had to examine whether the results of the new questionnaire are consistent with the results of other established measures. Therefore, we looked for expected correlations of ADOPTA playing styles with the Honey and Mumford's learning styles as well as previous gaming experience and gameplay preferences. For this purpose, we

combined several questionnaires, together with some questions about player demographic data, and four lie scales questions, namely:

- Questions about player's demography including sex, age, marital and working status, and education;
- Questions about previous gaming experience taken from Ventura et al. (2012):
 - Concerning the amount of video game play: average hours of video games played per week (0–1 h, 2–6 h, 7 h or more); total hours spent on favorite video games (1–10 h, 11–50 h, 51 h or more); number of different video games typically played in a year (0–3 games, 4–6 games, 7 games or more);
 - Concerning preferred game type - the respondent was asked to rate how much he/she enjoys playing the following types of video games: fighting, role playing games (RPG), action-adventure, puzzle, social media, platformers, strategy, simulations, shooters, and serious games. The 5-grade Likert scale was applied with possible answers as follows: 1–totally disagree, 2–somewhat disagree, 3–cannot decide, 4–somewhat agree, 5–totally agree.
- ADOPTA PSQ (40 dichotomous questions plus two supplemental lie scale questions);
- Honey and Mumford LSQ (40 dichotomous questions plus two supplemental lie scale questions).

All the questionnaires were administered online in adaptive computerized mode, with skip logic controlling the selection of items. Lie scale questions (Meade & Craig, 2012) were introduced to both ADOPTA PSQ and Honey and Mumford's LSQ in order to identify inattentive or careless responses in survey data. For eliminating potentially erroneous analytic results, such responses should be excluded from the data set.

4.2. Participants and procedure

The practical experiment implied online administration of a joint survey of questions about player demography, gaming experience, playing styles, learning styles, and personality characteristics (not discussed in this article). From November 2015 until March 2016 we collected data from 315 Bulgarian respondents - students at Sofia University 'St Kl. Ohridski', Technical University of Sofia, and Plovdiv University 'P. Hilendarski' (for this purpose, all the questions were translated into Bulgarian). The participation of respondents was voluntary. They were invited to participate in the survey through personalized emails. The purpose of the study was explicitly explained to the participants in both the invitation to

participate and the introduction page of the questionnaire. The joint questionnaire was published at SurveyMonkey and potential respondents were asked to complete it anonymously. There were no time limits for responding to the questions. As an incentive for taking the time to participate, after the results were processed each respondent received information about his/her personal playing and learning styles.

4.3. Results

The initial data set was formed based on the answers of 315 respondents. However, 55 of them had answered controversially some of the lie scale questions introduced to both ADOPTA PSQ and Honey and Mumford's LSQ. Such responses indicate inattentive or careless behavior and introduce error variance, which might attenuate correlations and reduce estimates of internal consistency and reliability; therefore, they were discarded. Of the other 260 respondents, 146 were men; 212 were single; 168 were third- and fourth-year undergraduate students; 100 reported being very good or excellent students; and 83 reported being employed. Descriptive statistics of demographic data and reported amount of video game play are presented in Table 2 (*M* stands for mean, and *SD* is standard deviation). Except for age and gaming experience, skewness and kurtosis are between -2 and $+2$, which supposes normality of distribution.

229 of all 260 respondents, who reported having previous gaming experience, were asked about their amount of video game play (Fig. 2) and preferred game type (Table 3). When asked about the amount of video game play, a majority of respondents appeared to be low habitual players playing less than 1 h per week ($M = 1.716$, $SD = 0.780$). However, more than 37% reported to be highly selective, i.e. playing their favorite game for more than 51 h. Highly diverse players (with 7 or more games played per year) comprised only 29 of all 260 respondents.

Table 3 summarizes descriptive statistics about the preferred types of commercial games for entertainment, applying the 5-grade Likert scale. The most preferred types of games are strategy, serious games, RPG, puzzles and platformers.

Playing and learning styles were calculated using ADOPTA PSQ and Honey and Mumford's PSQ. Fig. 3 depicts a comparison of box plots of both playing and learning styles. As far as both the style families are based on Kolb's experiential learning theory, results for playing styles are similar to those for learning styles. Only for the Dreamer-Reflector couple did the medians, quartiles and whiskers appear to be different, but the effect size of mean difference is small (Cohen $d = 0.20027$). Skewness and kurtosis for all the styles are between -0.826 and $+1.239$, which assumes normal distribution.

5. Data analysis

5.1. Correlation analysis

5.1.1. Internal consistency

The internal consistency of questionnaires is traditionally assessed by means of Cronbach's alpha statistic indicating inter-



Fig. 2. Playing experience - amount of video game play.

relatedness of the items, i.e. whether items assessing a given concept in a unidimensional scale yield similar results. For the four playing style scales, the internal consistency analysis resulted in values of alpha of 0.63606 for Competitor, 0.80414 for Dreamer, 0.78935 for Logician, and 0.70201 for Strategist. According to generally accepted practices, these values indicate good internal consistency for Dreamer, acceptable for Logician and Strategist, and questionable for Competitor. However, Cronbach's alpha depends on the number of items; for shorter tests, it has naturally reduced values (Tavakol & Dennick, 2011). Therefore, for shorter scales such as the one applied in the survey (10 items per concept) estimates below 0.7 can be accepted.

5.1.2. Concurrent validity

We looked for strength of association between pairs of ranked scores for the styles. Tables 4 and 5 present rank-order correlations between playing styles and learning styles, respectively (statistically significant values are given in bold). Spearman's correlation coefficient r_s has from low to moderate positive values for the couples Dreamer-Logician, Dreamer-Strategist, and Logician-Strategist. Competitor is negatively associated to Dreamer. The same appears for the rank-order correlations between learning styles. Next, Table 6 contains r_s values of all possible rank-order correlations between playing and learning styles. Strong correlations are found for the couples of styles proposed in section 4 and presented on the diagonal of the table. The rest r_s values reflect the inner-style correlations of Tables 4 and 5. The results provide evidence of good concurrent validity of the questionnaire.

We continued the concurrent validity analysis by searching for correlations with constructs other than styles. Table 7 presents Pearson's correlations of playing styles with types of games, where statistically significant correlations are presented in bold for significance levels of 0.05, 0.01 and 0.001. As expected, Competitors are fond of fighting and shooter games, Dreamers play more puzzles than other gamers do, Strategists like RPG and strategy games, and all Dreamers, Logicians and Strategists enjoy playing serious games, though these correlations are weaker than expected.

5.1.3. Test-retest reliability

Test-retest reliability is a simple method for verifying both the stability and reliability of a measuring instrument over time. The method was used for assessing how consistent the results measured by means of ADOPTA PSQ are over two time periods – two and four months. 18 out of all 260 participants took part in two other experiments (in February and June 2016) aiming at the automatic recognition of ADOPTA playing styles through an

Table 2
Respondent demographic data and amount of video game play ($N = 260$).

Statistic	Age	Gender balance	Student year	Grades	Employed	Gaming experience	Hours weekly	Hours/game	Games/year
<i>M</i>	27.917	0.562	3.359	4.733 ^a	0.681	0.900	1.333	1.852	1.407
<i>SD</i>	7.532	0.498	0.997	0.746	0.477	0.305	0.620	0.864	0.636
Skewness	1.819	0.444	-1.097	-0.466	-0.648	4.344	0.540	-0.128	1.056
Kurtosis	4.171	-1.816	0.853	-0.862	-1.588	17.248	-1.154	-1.727	-0.246

^a according to the Bulgarian national grading system, 2 = F is the lowest and 6 = A is the highest grade.

Table 3
Playing experience - preferred game types.

Statistic	Fighting (Street Fighter)	RPG (World of Warcraft)	Action adventure (Legend of Zelda)	Puzzle (Tetris)	Social media (Farmville)	Platformer (Super Mario Bros)	Strategy (Civilization)	Simulations (The Sims)	Shooters (Call of Duty)	Serious games(for education)
<i>M</i>	2.556	3.385	2.784	3.276	2.231	3.106	3.538	2.917	3.283	3.519
<i>SD</i>	1.410	1.591	1.377	1.449	1.400	1.485	1.425	1.538	1.506	1.254
Skewness	0.351	−0.426	0.034	−0.352	0.684	−0.207	−0.588	0.017	−0.383	−0.652
Kurtosis	−1.263	−1.402	−1.274	−1.279	−0.975	−1.387	−0.987	−1.492	−1.319	−0.395

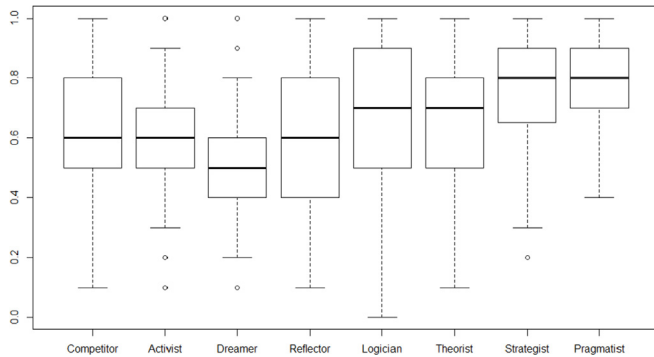


Fig. 3. Comparison of box plots of results found for ADOPTA playing styles and for Honey and Mumford's learning styles.

Table 4
Rank-order correlations between playing styles ($df = 258$).

r_s	Competitor	Dreamer	Logician	Strategist
Competitor		−0.30887*	−0.08617	0.05601
Dreamer			0.34186*	0.25873*
Logician				0.50244*
Strategist				

* $p < 0.0001$

Table 5
Rank-order correlations between learning styles ($df = 258$).

r_s	Activist	Reflector	Theorist	Pragmatist
Activist		−0.35042**	−0.22655*	0.10761
Reflector			0.42019**	0.24559**
Theorist				0.38250**
Pragmatist				

* $p < 0.001$

** $p < 0.0001$

Table 6
Rank-order correlations between playing and learning styles ($df = 258$).

r_s	Activist	Reflector	Theorist	Pragmatist
Competitor	0.72847***	−0.31588***	−0.13699*	0.10246
Dreamer	−0.33254***	0.69756***	0.38225***	0.21138**
Logician	−0.16669*	0.34944***	0.80945***	0.38022***
Strategist	−0.03462	0.25295***	0.50249***	0.67979***

* $p < 0.05$

** $p < 0.001$

*** $p < 0.0001$

adaptive video game (Bontchev, 2016). After the game sessions, they were asked to fill out the same PSQ. Table 8 presents the assessment results of test-retest reliability of ADOPTA PSQ. For the two months period, Pearson's r has values from 0.80935 for

Table 7
Correlations of playing styles with preferred genres of games.

Game genre	Competitor	Dreamer	Logician	Strategist
Fighting	0.17518**	0.01796	−0.00602	0.03630
RPG	0.13236	0.08844	0.16400	0.20182*
Action adventure	−0.03246	0.07919	−0.00602	0.03630
Puzzle	−0.02361	0.10919*	−0.05030	0.05504
Social media	0.02590	0.05875	0.01535	0.00401
Platformer	0.12434	0.06825	0.01577	0.09427
Strategy	0.07894	0.00362	0.10371	0.20613**
Simulations	0.04220	0.01415	−0.08484*	0.02901
Shooter	0.23923***	−0.08088	0.08800	−0.08088
Serious games	0.02744	0.25900***	0.17178*	0.25106**

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Logician up to 0.96910 for Strategist, indicating high reliability over a relatively shorter time. As expected, for the four-month period r is rather lower yet pointing out statistically significant medium or high correlations.

5.2. Factor analysis

The results of the pilot study were analyzed, first applying exploratory factor analysis (EFA) and then confirmatory factor analysis (CFA).

5.2.1. Exploratory factor analysis

The goal of EFA was to investigate the consistency of the questions of the developed questionnaire (ADOPTA PSQ) and the existence of relationships between items. Beforehand, two tests for sampling adequacy were carried out - the Kaiser-Meyer-Olkin test and Bartlett's test of sphericity. The results presented in Table 9 provide a reasonable enough basis that the collected data can be interpreted as reliable and appropriate for applying structure detection methods to them.

The conducted EFA identifies four number of factors (Fig. 4) explaining 48% of the variation in the data set. For selecting the number of factors, we applied parallel analysis (Horn, 1965) and the Kaiser-Guttman criterion for eigenvalues greater than one (Barrett & Kline, 1982). Thus, we found the number of factors matches the number of scales. Table 10 shows factor loadings received after a Varimax rotation for each item named as Play N (N is the question number), where significant values for a factor are marked in bold. For cases where more than one value is identified as significant (because several factor loadings have very similar values or one of the values is negative, but has high absolute value), the selection (given in a grey background) is done based on the factor that better explains the corresponding item. The negative loadings are taken into account because they reveal the direction of the correlation and have no effect on the interpretation of the magnitude (Yong & Pearce, 2013).

The names of the four factors - Logician, Competitor, Dreamer, and Strategist - correspond to those of the playing styles. The

Table 8
Assessment of test-retest reliability of ADOPTA PSQ (N = 18).

Playing style	Time period	r	p
Competitor	DEC/FEB	0.98099	0.0000
	FEB/JUN	0.91829	0.0000
Dreamer	DEC/FEB	0.94037	0.0000
	FEB/JUN	0.77704	0.0001
Logician	DEC/FEB	0.80935	0.0000
	FEB/JUN	0.57621	0.0123
Strategist	DEC/FEB	0.96910	0.0000
	FEB/JUN	0.51331	0.0294

Table 9
Results of KMO and Bartlett's tests.

Kaiser-Meyer-Olkin measure of sampling adequacy		0.864
Bartlett's test of sphericity	Approx. chi-square	3510.055
	Df	780
	p-value	0.0000

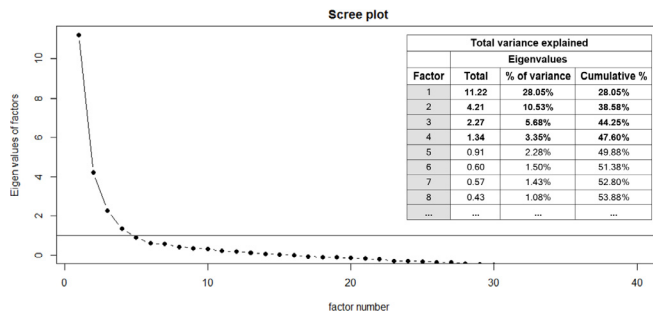


Fig. 4. Scree plot and total variance explained.

Table 10
Factor loadings.

Factor score coefficient matrix									
Item	Factor				Item	Factor			
	Logician	Competitor	Dreamer	Strategist		Logician	Competitor	Dreamer	Strategist
Play 1	-0.01480	0.45521	-0.23226	0.28408	Play 22	-0.58440	0.22601	-0.48252	0.21119
Play 2	-0.14541	-0.43839	0.01339	-0.16336	Play 23	0.32845	-0.09223	0.69742	0.13845
Play 3	0.41266	-0.02856	0.25950	0.08182	Play 24	0.68821	0.07656	0.34667	0.00630
Play 4	0.28003	-0.00422	0.14895	0.57744	Play 25	0.31299	0.06550	0.36819	0.50939
Play 5	-0.45549	0.27851	-0.18271	0.00866	Play 26	0.02623	0.47567	0.05534	-0.19063
Play 6	0.41057	-0.20766	0.35585	0.12134	Play 27	0.07942	0.22521	0.38786	0.18883
Play 7	0.31222	0.42857	0.17798	0.27828	Play 28	0.25270	0.03115	0.14121	-0.02068
Play 8	0.38953	-0.24131	0.15968	0.31434	Play 29	-0.27512	0.08274	-0.02215	0.08751
Play 9	-0.14844	0.61009	-0.09322	0.26481	Play 30	-0.02462	0.33038	0.33174	0.03496
Play 10	0.33605	-0.18890	0.59058	0.17397	Play 31	0.08634	-0.58219	-0.16111	-0.04737
Play 11	0.47499	0.04971	0.43429	-0.00282	Play 32	0.51212	0.53961	0.12095	0.13549
Play 12	0.64453	-0.00807	-0.02614	0.76084	Play 33	0.12113	-0.06634	0.00386	0.32522
Play 13	-0.60513	0.26261	-0.38346	0.20853	Play 34	-0.27283	-0.07254	-0.27367	0.15072
Play 14	0.02369	-0.44871	0.03221	0.08091	Play 35	0.19111	0.12393	0.48472	0.26978
Play 15	0.52250	0.07979	0.19746	0.13710	Play 36	0.30505	0.19497	0.61331	-0.02824
Play 16	0.30248	0.28418	-0.01393	0.55735	Play 37	0.12073	0.46243	0.11090	0.16017
Play 17	0.33962	0.54741	0.09270	0.11604	Play 38	0.10310	0.58561	0.12026	0.10088
Play 18	-0.54964	-0.03067	-0.01650	0.26563	Play 39	0.05624	-0.34075	0.48916	0.02301
Play 19	0.40789	0.03484	0.34133	0.04708	Play 40	0.25052	0.40390	0.30485	0.08118
Play 20	0.40009	0.12523	0.31473	0.27709	Play 41	-0.68884	-0.00352	0.01968	0.72121

distribution of items according to the EFA significantly resembles the initial distribution of the items among the styles as given in the [Appendix](#). Questions that do not meet the initial configuration have to be reworded and clarified. For instance, the factor Logician contains items *Play 3*, *Play 11*, *Play 15*, *Play 19*, *Play 20*, *Play 24*, *Play 28*, and *Play 32*. Almost all questions are used for identifying Logician and one of them (*Play 20*) is for Strategist. Since question *Play 20* (“I think long-term when planning my gaming strategies”) emphasizes more long-term thinking than planning gaming strategies, this feature (long-term thinking) is shared among Logician, Strategist, and Dreamer. Therefore, the item should be either reworded (for instance “I plan my gaming strategies in the long-term”) or excluded from the questionnaire.

5.2.2. Confirmatory factor analysis

To verify the structural validity of the scales, a CFA was conducted. We analyzed missing values from the data set using Little's Missing Completely At Random (MCAR) test ([Schafer & Graham, 2002](#)). We found $\chi^2 = 357.6955$, $df = 305$, p -value = 0.0203 that was sufficient to reject MCAR. Following the distribution of items in the four scales obtained during the first phase of the factor analysis, we constructed a model presenting standard relationships between each one individual latent variable and all observed variables, as well as between latent variables. This model is shown in [Fig. 5](#), where rectangles represent observed variables (items of the questionnaire), bigger circles show latent variables, and smaller circles depict residual variations (e_i). The correlation coefficients between the four factors depend on factor loadings and have very good values (between 0.854 and 0.962). The results received from the CFA for the constructed model reveal error RMSEA to be 0.025 and fit indexes CFI = 0.966 and NFI = 0.806 ([Jackson, Gillaspay, & Purc-Stephenson, 2009](#)). They give us enough evidence that the applied methodology for measuring playing

styles is sufficiently reliable and constructively valid for our sample.

6. Discussion

The general goal of the present study was to design and validate a questionnaire for the assessment of playing styles based on Kolb's theory of experiential learning (Kolb, 1984). Based on both the experience and observation knowledge of experts in game-based learning, we identified key features of playing digital games applied for education. These features were allocated on Kolb's two-dimensional space sized by the Processing and Perception continuums and were applied for designing the questionnaire items. The item design procedure involved selection of 10 items for each style identifying how the player approaches a game task, i.e. how he/she thinks or feels about the task.

In order to do initial validation of the questionnaire, we conducted a pilot study with online administration of a joint questionnaire that addresses both ADOPTA playing styles and Honey and Mumford (1992) learning styles along with previous gaming experience. The selected sample size was greater than the minimum sufficient for factor analysis. Before looking for descriptive statistics of collected data, in order to avoid potentially erroneous analytic results, we excluded from further analysis inattentive or careless survey responses. We identified them by means of four lie scale questions (Meade & Craig, 2012) – two for ADOPTA PSQ and two for Honey and Mumford's LSQ. For the rest of the 260 responses, we found normally distributed data and did correlational and factor analyses.

Concurrent validity of the PSQ was tested using two approaches: by rank-order correlations between playing and learning styles (since they both represent similar concepts reflecting perception and processing of information in the context of games and learning, respectively) and, as well, by correlations between playing styles and genres of contemporary video games (Ventura et al., 2012). Strong rank-order correlations between ADOPTA playing styles and Honey and Mumford's learning styles provide evidence for good

and statistically significant consistency of playing style concepts with scores of similar measures already established in the domain of learning. On the other hand, low and moderate correlations of playing styles with games genres reveal an anticipated preference for playing games containing tasks, which are typical for each playing style.

Based on the strong correlations obtained in the scope of the test-retest study, we can claim that our PSQ is a reliable survey tool. However, its internal consistency appeared to be lower than expected, namely good for the Dreamer style, acceptable for Logician and Strategist, and questionable for Competitor. Although for a relatively small number of items Chronbach's alpha tends to have reduced values (Tavakol & Dennick, 2011), this relatively lower consistency made us conduct two types of factor analysis – exploratory and confirmatory. The EFA identified four factors. Obtained factor loadings were good for the majority of items, but we identified several items that should be reworded or excluded from later studies. Finally, the CFA helped us to verify the structural validity of the scales. It confirmed a good fitting of the model to the four factors previously established by the EFA. In order to ameliorate it, we have to remaster the problematic items as discussed in 6.2.

The importance of a validated and reliable instrument for measuring playing styles is crucial for game designers and practitioners. The ADOPTA PSQ can be used in pre- or post-game administration mode for assessing individual playing style, in order to be applied to the implementation of a style-based adaptation of either a video game (Cowley, Charles, Black, & Hickey, 2013) or a game-based personalized learning platform (Vassileva, 2012). Furthermore, PSQ can be used for the validation and tuning of video games that provide an implicit automatic assessment of the playing style (Bontchev & Georgieva, 2017).

7. Limitations

The present study suffers from several limitations related to the quality of content of some items, sample size of respondents, and the dichotomous scale applied in ADOPTA PSQ. The pilot was limited by the problems found by the factor analysis of the items in the initial version of the questionnaire. Later studies of the same family of playing styles should use a new version of the PSQ, remastered according to the considerations of each item discussed in the previous section. Thus, reworked items are supposed to identify the playing style concepts more accurately and with better recall. In addition to the reworking of items, new PSQ versions can use a different scale. For the pilot study, the dichotomous scale was chosen for a direct comparison with scores of Honey and Mumford's LSQ. Instead of dichotomous response scales, where the respondent has only two options, a large-scale study should apply items with an ordinal scale allowing a better factor analysis.

The sample size used for this pilot study was bound by the recommended minimum sufficient to perform factor analysis for this number of variables (Hatcher, 1994). Osborne and Costello (2009) reported the majority of researchers perform analyses with a subjects to item ratio of 10:1, which implies administration of PSQ to at least 400 respondents for subsequent studies. On the other hand, analysis of test-retest reliability was limited by a relatively small number of respondents, which was due to the need for the participation of one person several times. Therefore, the next reliability studies should address this problem as well.

Finally, the results presented here address mainly relationships between playing and learning styles. Further analysis is required for investigating other dependencies between playing styles and playing experience, including the amount of video game play and preferred game genres. In addition, later studies should consider

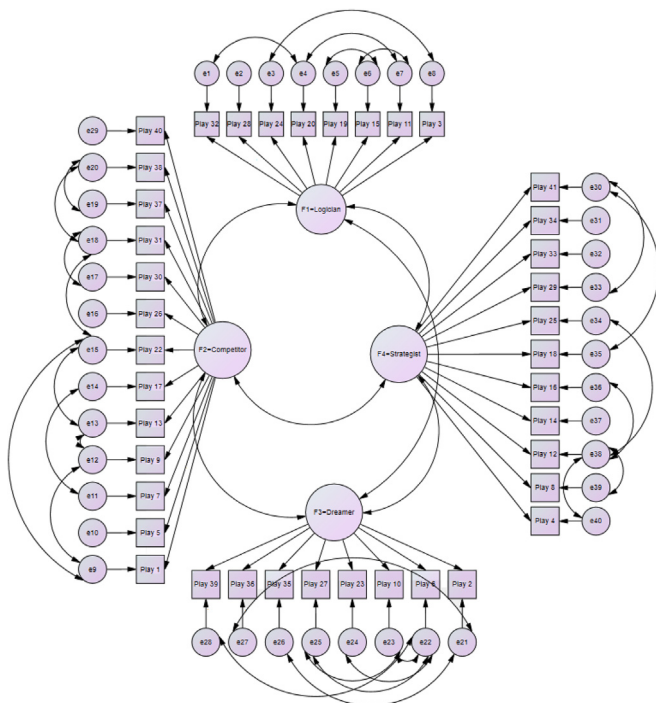


Fig. 5. View of the structural model of CFA.

other relationships between playing style and various player's characteristics, such as style dependencies on personality traits.

8. Conclusions

Both learning and playing styles represent an important basis for player-centric models allowing researchers and game designers to adapt various features of the mechanics and content of video games geared towards education and training. As stated by [Brisson et al. \(2012\)](#), user models for interactive learning do need to adapt to different user learning styles and overall preferences in a proper way. For the creation of both pleasurable and useful educational games, player-centric adaptation mechanisms must address the player context as a whole, including the psycho-cognitive abilities and skills of the player with respect to learning, motivation, and creativity. Playing styles can be applied for flexibly and efficiently tailoring educational games to the intellectual abilities, personality and intrinsic and extrinsic motivations of players ([Magerko et al., 2008](#)).

The pilot study presented in the article was intended to highlight the scope of the playing style questionnaire and to evaluate both the expressiveness and accuracy of its items by using a restricted sample size. The results of the pilot were rather positive overall. The conducted data analysis demonstrated a very good test-retest reliability of the questionnaire, despite it being based on a small sample size. The presented correlations between playing styles and both Honey and Mumford's learning styles and various game genres show a good concurrent validity of the questionnaire. The internal consistency was found to be acceptable and has to be increased following the conclusions for reworking or omission of some items resulting from conducting the EFA and CFA. The new, reworked version of the playing style questionnaire has to be analyzed and validated in a second pilot study before administering it to a large-scale sample size.

Future large-scale studies can address dependency issues of playing styles concerning their correlations to the gaming experience, gameplay characteristics, potential cultural bias, and personality traits and, additionally, learning outcomes in game-based learning in the context of personalized and adapted gameplay ([Bontchev, 2016](#)). In order to achieve an effective and efficient style-

based adaptation in serious games, playing or learning styles should be assessed accurately either by pre-game self-reporting or by tracking and analyzing a player's behavior during the game playing session, in an implicit and automatic way. The second approach is very intriguing and promising, due to the fact that players are not aware of the process. It may apply various design techniques but it always requires validation by means of comparing automatically recognized styles to those obtained by self-report. Automatic recognition methods may categorize playing styles by means of self-organizing maps ([Wong, Kim, Han, & Jung, 2009](#)) or fuzzy cluster analysis and hidden Markov models ([Etheredge, Lopes, & Bidarra, 2013](#)). [Cowley et al. \(2013\)](#) compared several classifiers for dichotomous classification in binary classes (such as manager versus non-manager) and obtained the best accuracy of nearly 72%. Recently, multiple linear regression over task performance metrics was validated as an effective instrument for the automatic estimation of both the ADOPTA playing styles and the learning styles of Honey and Mumford, with an average accuracy of estimation equal to 76.51% for playing styles and 82.71% for learning styles ([Bontchev & Georgieva, 2017](#)). Thus, by applying an analysis of player behaviors at runtime in an implicit way for a player, the automatic assessment of playing and/or learning styles provides a basis for the dynamic style-based adaptation of various game features. Future studies have to investigate and reveal the full potential of style-based adaptation regarding its impact on overall playability and learning outcomes.

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Appendix: ADOPTA PSQ

No	Question	Playing style
1	When playing I often take great risks that seem to me reasonable.	Competitor
2	I prefer to observe the gameplay instead of controlling it.	Dreamer
3	I like logic, analysis and pattern-based approaches for executing any task in the game.	Logician
4	I like resolving complex problems within a game in the most effective way.	Strategist
5	I rely mostly on my intuition rather than theoretical analysis.	Competitor
6	I like guided gameplay and staying at a given game level until I have mastered it sufficiently.	Dreamer
7	I have good spatial awareness and contextual thinking.	Logician
8	I do not like acting/shooting without reasonable expectations of good results and benefits in the game.	Strategist
9	I find spontaneous actions and strong competition to be the greatest opportunities for discovering new things and ideas in games.	Competitor
10	I need to gather different perspectives about a game's missions and to consider them carefully before starting actively playing.	Dreamer
11	I learn the intricacies of each game rule.	Logician
12	I try to find practical ways to fulfill the game tasks on time.	Strategist
13	I prefer to solve problems using trial and error methods rather than first undertaking a deeper analysis.	Competitor
14	I do not like fixed time missions and need to think as long as I require.	Dreamer
15	I try to apply each game rule in a rational and optimum way.	Logician
16	While playing a game, I seek opportunities to apply them for reaching practical outcomes.	Strategist
17	I am good in critical situations in gameplay, which requires the preservation of composure and self-control.	Competitor
18	When playing, I am quite open about my feelings.	Dreamer
19	I like exploring the game space and facts in a stepwise, detailed and precise way.	Logician
20	I think long-term when planning my gaming strategies.	Strategist
21	I prefer to manage the gaming process rather than observe it. (complementary to Question 2)	Lie scale
22	I prefer to start active playing as soon as possible, without reading instructions or too much planning.	Competitor

(continued on next page)

(continued)

No	Question	Playing style
23	I prefer to observe and to listen to the arguments of the others before taking decisions in a game.	Dreamer
24	I like to assemble the gameplay facts into a coherent rational scheme and to use it to come up with game tactics and strategies.	Logician
25	I like decision-making, testing hypotheses and seeing the practical consequences of my experiments and the actions I have taken.	Strategist
26	In teamwork gameplay, the others usually regard me as the most active player.	Competitor
27	In games, I am fond of social interaction, diplomacy, and negotiation.	Dreamer
28	In debates with other players, I do not implicitly trust the others' arguments and assumptions but want to check and logically test everything.	Logician
29	I like anything, which works.	Strategist
30	I like to share my achievements with the others.	Competitor
31	I do not like to play an active part in a discussion.	Dreamer
32	In discussions with others players, I try to establish and impose rational, time-based approaches.	Logician
33	I try never to abandon my realism.	Strategist
34	I do not like debating the appropriateness and consequences of players' actions excessively.	Competitor
35	I like considering the actions of the other players while thinking about all possible consequences.	Dreamer
36	In debates, I like to combine existing opinions and ideas in a logical and uncontroversial way.	Logician
37	I have good management skills and like to coordinate the teamwork while playing a game.	Strategist
38	In discussions, I prefer to talk and convince others of my intuition.	Competitor
39	I prefer playing through clear game scenarios instead of having an emergent gameplay.	Dreamer
40	I like to be recognized by the others players as being rational, methodical and objective.	Logician
41	I am probably sometimes impatient about seeing/receiving immediate practical benefit from the results of my actions.	Strategist
42	In critical situations in the game, I often lose my composure and self-control. (complementary to Question 17)	Lie scale

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