

ICHEU 2021
International Conference «Humanity in the Era of Uncertainty»**FEATURES OF SIMULATION OF SELF-REGULATED
LEARNING OF STUDENTS IN THE STUDENT GROUP**

Alexander V. Kaptsov (a)*, Igor B. Akimov (b), Ekaterina V. Nekrasova (c)
*Corresponding author

(a) Moscow City Pedagogical University, Samara branch, st. Stara Zagora, 76, Samara, Russia, avkaptsov@mail.ru

(b) St.Petersburg Humanitarian University of Trade Union, Samara branch, st. Frunze, 144, Samara, Russia,
fort077@gmail.com

(c) Tolyatti State University, st. Belorusskaya, 14, Tolyatti, Russia, Ekaterina-nekrasova-0782@yandex.ru

Abstract

One of the modern approaches describing the success of learning in a situation of uncertainty is an ontological model of the stages and ways of the students' agency formation, and the ways of performing educational actions correspond to the principle of fractality due to the stages of agency formation. A model of self-regulating learning in a study group is proposed, in which the methodological technique of cross-delayed correlation is used to obtain causal relationships between individual stages and methods of performing educational actions. Empirical studies conducted on samples of 59 university students ($M=19.52$; $SD=2.36$; all women) and 45 students of secondary vocational education ($M=16.81$; $SD=0.69$; 98 per cent young men) showed that there is an influence of the stages of agency formation on the ways of performing educational actions, which in turn affect the stages of agency formation. The condition of self-regulation of learning with the allocation of attractors according to the mathematical theory of dynamical systems has not been confirmed. The absence of attractors in the third-year study group is due to the mixed learning of students both in distance and in traditional full-time forms. The absence of a specific structure in the educational environment created conditions of uncertainty that influenced the formation of self-regulated learning.

2357-1330 © 2021 Published by European Publisher.

Keywords: Self-regulated learning, cross-delayed correlation, stages and ways of agency formation



1. Introduction

The development of integrative approaches to understanding the multicomponent regulation of educational activity from the intellectual and personal potential of the student has led to new formulations of the problems of psychological factors of learning success in modern educational psychology (Kornilova, 2016). The personal characteristics of self-regulation associated with various aspects of the attitude towards uncertainty include willingness to take risks, rationality, and the ability to rely on intuition (Kornilova, 2016, p. 173). The latter in the theory of self-understanding of the subject refers to the existential experience of a person (Znakov, 2016). Personal characteristics, reflecting individual differences in attitudes towards uncertainty, are especially relevant for the theory of self-regulatory learning, because they manifest themselves in various communicative contexts, in coping with learning difficulties and challenges (Jordan, 2015; Poddyakov, 2014; Sorrentino et al., 2013).

Learning as a process of acquisition of knowledge includes multiple acts of decision-making and solving various problems, based on the student's ability to cope with novelty and uncertainty (Bauman, 2013; Kornilova, 2016). A significant contribution to the idea of interiorization as a process of transformation of external forms of activity into psychological new formations was made by Galperin (1992) in his concept of the phased formation of mental actions. Mastering a new skill or concept should not start from a finished form (Zhdan, 2017). It is necessary to reconstruct the entire complete composition of the process, which objectively lies behind the finished form and which the student must carry out. Abroad, the theory of the stage-by-stage formation of mental actions found its continuation in the theory of experimental learning by D. Colby (as cited in Passarelli & Kolb, 2012). The considered concepts relate to the epistemological paradigm, phenomenologically presented in the form of mental processes, conditions, consciousness, abilities and behaviour of a person who is in interaction with the environment (Panov, 2020). Whereas the mental process of generating these product, phenomenological manifestations of the mental act itself remains hidden from internal and external observation. From the ontological paradigm, the formation of mental phenomena as an actual form of the psyche's existence occurs "in the gap" of the "individual – environment" system. Panov (2014) proposed an ontological model of learners' agency formation, according to which subjectivity in its development must go through a number of stages from actual to potentially possible forms. Each of the stages, in turn, consists of ways of performing educational actions that correspond to the principle of fractality (Kaptsov & Panov, 2020). On the other hand, the students' group is a self-organizing and self-developing system for which the theory of complex dynamical systems can be used (Kaptsov & Nekrasova, 2021). In social psychology, foreign authors (Pozdnyakov, 2020; Richardson et al., 2014; Steenbeek & Van Geert, 2008; Vallacher & Nowak, 1994; Watters et al., 1996) describe the prospect of applying the theory of dynamical systems in modelling and explaining various phenomena in socio-psychological research, such as social relations, attitudes, social cognition and interpersonal behaviour, which change over time.

The principles of the theory of dynamical systems can also be applied in educational psychology in the study of cognitive processes of students, groups of students, motivation for learning and the dynamics of teaching and learning (Abraham, 2003). Self-regulated learning is understood as the establishment of a relationship between the system of stages of agency formation in educational activity and the system of

methods for performing educational actions within the educational group. To diagnose this mode, an assessment of the stages and methods of performing educational activities on the same sample of students is carried out twice with an interval between measurements of several months with the subsequent determination of the correlation relationships between the components of students' agency formation.

2. Problem Statement

The problem of this study is to determine the internal and external factors of the stages and ways of students' agency formation, contributing to the emergence of a mode of self-regulation of educational activity in a small academic group. The paper (Kaptsov & Nekrasova, 2021) shows that when students interact in a study group, phenomena of self-organization arises, described by nonlinear equations of change in the severity of individual stages of agency formation according to the theory of dynamic systems. In particular, it is shown that in the second year of university students, the self-regulation mode appears at the stage of "student" and "master". However, the stages of agency formation, as shown in the work (Kaptsov & Panov, 2020), consist of seven ways of performing educational actions, which are fractal relative to the stages. Our research displays that the stages and ways of agency formation are interconnected. At the same time, the influence of this relationship on the mode of self-regulation of learning has not been studied.

3. Research Questions

The research had the following tasks:

- to identify approximate causal relationship between the stages of students' agency formation and ways of performing educational actions;
- for the identified causal relationships to determine their features for different years and levels of education;
- to identify the conditions for the emergence of attractors in the system of stages and methods of agency formation of educational actions.

4. Purpose of the Study

To identify internal conditions in the system of stages and methods of agency formation of students, leading to the emergence of a mode of self-regulation of learning.

5. Research Methods

The empirical study was carried out on a sample of 59 university students ($M=19.52$; $SD=2.36$; all women) and 45 students of a technical college ($M=16.81$; $SD=0.69$; 98 per cent young men). The Questionnaire of the Stages of Agency Formation was used to study the severity of the stages of agency formation (QSA-F4) (Kaptsov & Nekrasova, 2021). An approximate causal relationship between the stages and ways of agency formation was determined using the methodological technique of cross-delayed correlation (Kornilova, 2018). The time interval between two measurements for determination of attractors and approximate causal relationships was seven months.

6. Findings

As a result of empirical research in a sample of 3rd year students, the relationship between the first and second dimensions of the stages and ways of agency formation was revealed. Table 1 shows the results of cross-delayed correlation between the stages of agency formation in the first dimension and methods in the second dimension.

Table 1. Correlation matrix between the stages of agency formation of the first dimension and the methods of the second dimension

Stages of agency	Goal setting	Observation	Imitation	Teaching	Critic	Creation
The observer						0.38
The apprentice						
Critic					0.33	
Master	0.35	0.41				
The creator		0.35	0.32	0.45		

From table 1, we can conclude that there is an approximate causal connection between the stage "creator" and the method of observation in the second dimension, that is, the development of students' creative thinking stimulates the formation of a method of observation in further educational activity (Kendall's tau - 0.35). At the same time, there is a relationship between the observation method of the second and first dimensions (Kendall's tau - 0.322). Anokhin (1978) wrote that in functional systems "the parameters of the result are formed by the system in the form of a certain model before the result itself appears" (p. 76). This fact is also indicated by Boldachev (2007) "the image of the result is formed by the functional system in advance, that is, it precedes the action". The influence of the "future" on the "present" is due to the degree of awareness of the individual (Barrett, 2009) and the development of his emotional sphere (Williams, 2010). To confirm this fact, one-way analysis of variance (ANOVA) was carried out, confirming the effect of the observation method in the second dimension on the first dimension ($F = 4.497$ at $p = 0.026$). Consequently, the creation of an image of the studied educational action in the first dimension contributes to the formation of a method in the second dimension. Table 2 shows the results of cross-delayed correlation between methods in the first dimension and stages of agency formation in the second dimension.

Table 2. Correlation matrix between the ways of agency formation in the first dimension and the stages of the second dimension

Methods of training actions	The subject of motivation	The observer	The apprentice	Student	Critic	Master	The creator
Observation	0.35	0.32			0.31		0.49
Imitation			0.34				
Teaching	0.40			0.33			0.47
Excellence						0.41	0.40
Creation						0.35	0.48

From Table 2 it can be seen that there is an approximate causal connection between the method of formation of the action "observation" and the stage "creator" in the second dimension (tau-Kendalla 0.49).

Similarly to the one considered, as follows from Tables 1 and 2, there is an approximate causal connection between the stage of agency formation “creator” and the method of performing the educational action “learning”, and the influence of the method of learning in the second dimension on the first dimension ($F = 4.307$ at $p = 0.029$) the image of his future teaching, the formation of the way of performing actions occurs more strongly.

The study of the conditions for the emergence of the phenomenon of self-organization, described by nonlinear equations of change in the severity of individual stages of agency formation according to the theory of dynamic systems, showed that the self-organization mode of university students in the third year was not revealed at any stage, including the "creator" stage. But in the methods of performing educational actions, the initial conditions of self-organization in the "critic" method were revealed, which was not confirmed empirically.

7. Conclusion

One of the urgent problems of education is the transition from active subject-subject interactions in the system of student-educational environment to a self-regulating educational environment. The mathematical theory of dynamical systems allows proving the presence of self-organization in the system, but does not reveal the psychological conditions for the emergence of self-regulated learning. The paper proposes a model for diagnosing the conditions of self-regulating learning in a study group, which uses a methodological technique of cross-delayed correlation to obtain approximate causal relationships between individual stages and methods of performing educational actions. On empirical samples of university and technical college students, it is shown that the conditions for the emergence of self-directed learning are fully met in the third year of university students at the stage of agency formation of the "creator" and the methods of "observation" and "learning". However, the condition of self-regulating learning with the allocation of attractors according to the mathematical theory of dynamical systems has not been confirmed. Perhaps the absence of attractors in the third-year study group is due to the mixed learning of students either in distance or in traditional full-time forms during a pandemic, which influenced the system of interactions in the educational environment of the university, specifically, the absence of a certain structure in the educational environment or the creation of conditions of uncertainty.

Acknowledgments

The reported study was funded by RFBR and EISR according to the research project № 20-013-00238.

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