Development of the Spiral Gradual Release of Responsibility (GRR) Learning Model to Enhance Transfer of Learning in Econometrics

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Abstract

In the contemporary data-driven economic society, econometrics plays a pivotal role in not only elucidating complex economic phenomena but also furnishing a robust scientific foundation for economic decision-making. Despite advancements in econometric pedagogy, the challenge of translating theoretical knowledge into practical problem-solving skills remains pronounced. This article aimed to (1) develop a learning model that integrates spiral theory, learning strategies, and the Gradual Release of Responsibility (GRR) model to enhance students' transfer of learning and (2) evaluate the effectiveness of the Spiral GRR Learning Model in improving students' transfer of learning in econometrics.

The study was conducted with third-year economics majors at Zhanjiang University of Science and Technology, Guangdong, China, involving two classes selected through cluster sampling. One class, comprising 44 students, was designated as the experimental group and exposed to the Spiral GRR learning model, while the other class of 45 students served as the control group, receiving traditional instruction. Implemented over the second semester of the 2023 academic year, this intervention utilized test papers and interviews to collect quantitative and qualitative data, which were subsequently analyzed using descriptive and inferential statistics, alongside content analysis.

The research findings indicate that the Spiral GRR model effectively fosters the transfer of learning in econometrics, enhancing students' ability to apply knowledge across different contexts. Moreover, the study uncovered significant relationships between deep understanding of material and effective transfer, along with demographic influences such as gender and regional

background. The success of this model suggests potential applications for improving educational outcomes in various disciplines beyond econometrics.

Keywords: Spiral GRR Learning Model; Transfer of learning; Econometrics

Introduction

For economics majors, mastering econometrics is crucial for interpreting economic data, forecasting trends, and assessing policy effectiveness (Fang, 2020). However, students often struggle to apply econometric tools to problem-solving (Zhou, 2016). Education aims to foster transfer, enabling students to use knowledge and strategies in new contexts (Mayer, 2002; Mayer & Wittrock, 1996), but students frequently lack the skills to restructure their knowledge, and teachers may overlook cognitive skills and learning strategies (Jing, Li, & Hou, 2022).

Traditional econometrics teaching focuses on theory and model derivations, a 'spoon-feeding' approach that fails to develop deep understanding and flexible application of knowledge (McKee & Orlov, 2021). While studies highlight the importance of transfer and explore enhancement strategies (Shi et al., 2022), research on specific econometrics learning models is limited.

This article addresses two questions: (1) How can a learning model integrating spiral structure, learning strategies, and the Gradual Release of Responsibility (GRR) enhance transfer in econometrics? (2) How can its effectiveness be verified? The model will be implemented in an econometrics course at Zhanjiang University of Science and Technology, with data collected to assess its impact on student transfer abilities. Findings aim to advance pedagogical practices and inform similar course designs.

Research Objectives

1. To develop a learning model that integrates the spiral structure, learning strategies acquisition, and the Gradual Release of Responsibility (GRR) model, with the aim of enhancing economics students' understanding and transfer of learning in econometrics.

2. To evaluate the effectiveness of the developed learning model in promoting the transfer of learning among college students majoring in economics.

Literature Review

1. Research on knowledge spiral theory

The knowledge spiral theory, pioneered by Nonaka in 1994, views knowledge creation as an evolving spiral that signifies continuous learning and the progression of understanding. The spiral's design underscores the importance of ongoing educational processes and adaptability, illustrating how each cycle builds upon the last, thus fostering a steady accumulation of knowledge (Nonaka, 1994). Within this framework, knowledge creation is depicted as a series of spiraling stages, each integrating new insights and understandings, which enrich the collective knowledge base of an organization (Nonaka & Takeuchi, 2007). The spiral structure has been widely applied across various disciplines and educational fields. Shanahan, Tochelli–Ward, & Rinker (2019) discovered that teachers implemented three rounds of iterative GRR in strategy instruction.

Current research has begun to reveal the mechanisms, influencing factors, and application value of the spiral progressive learning model in educational practice. However, there are still limitations in the design, implementation, and evaluation of models. This article will apply spiral structures to the structural design of a learning model.

2. Research on Learning Strategies

Learning strategies encompass both cognitive and metacognitive strategies, empowering learners to achieve their desired learning aims (Fooladvand, Yarmohammadian & Zirakbash, 2017). A cognitive strategy is a means to achieve a cognitive goal (such as understanding or remembering) and involves potentially conscious and controllable activities (Pressley & Harris, 2009). Cognitive learning strategies encompass rehearsal strategies, organization strategies, and elaboration strategies (Weinstein, Husman & Dierking, 2000).

Metacognitive strategies can be subclassified into planning, monitoring, and evaluating (Flavell et al., 2002; Schraw & Dennison, 1994). Although they do not directly address information processing or motivational issues, they ensure that learners apply cognitive or motivational regulation strategies with high quality (e.g., Leopold & Leutner, 2015). Akpur (2021) also mentioned elaboration, organization, and rehearsal as cognitive strategies and planning, monitoring, and regulation as metacognitive strategies.

Research has shown that cognitive strategies and metacognitive strategies can improve students' performance and achievement (Fooladvand, Yarmohammadian & Zirakbash, 2017; Özkubat & Özmen, 2021; Saied & Mehrabi, 2013). Learning achievement is conducive to transfer (Pham & Huynh, 2018). In addition, metacognitive strategies are task–general and can be

transferred to new contexts and tasks once learned (e.g., Schraw & Nietfeld, 1998; Schuster et al., 2020; Veenman & Verheij, 2003). Researcher summarize the impact of learning strategies on learning and define what constitutes transferable content.

Table 1 Transferable Content

Transferable content	Subject matter knowledge
	Metacognitive strategies
	Cognitive strategy application experience

3. Research on GRR model

The Gradual Release of Responsibility (GRR) model, first introduced by Pearson and Gallagher in 1983, aims to enhance students' reading comprehension abilities (Pearson & Gallagher, 1983). The model has been revised to encompass more steps and has been adapted for various contexts, including applications beyond reading for diverse learners. It relies on educators designing and implementing various scaffolds or supports to guide students beyond their current levels (Salehomoum et al., 2022). In 2013, Fisher & Frey proposed a four-stage model: (1) Focused Instruction; (2) Guided Instruction; (3) Collaborative Learning; (4) Independent Practice (Fisher & Frey, 2013). This framework for the Gradual Release of Responsibility has gained widespread adoption.

Given that the GRR model is recommended for teaching any comprehension strategy (Pearson & Gallagher, 1983), this study employs it as a tool for shifting cognitive and metacognitive strategies from teachers to students. In the context of teaching and learning econometrics, students acquire cognitive and metacognitive strategies through these four steps.

The existing research is limited to the independent application of the above three theories, applying to the improvement of learning achievement, transfer of learning, and strategy understanding. This article will integrate the above three theories to design a learning model.

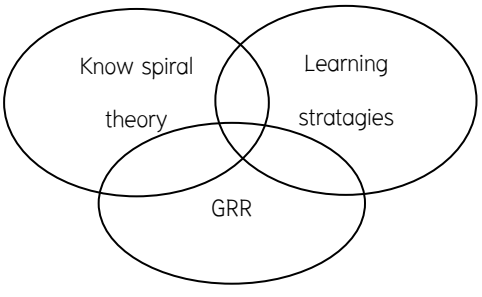

Fig.1 Integration of Three Theories

4. Research on the transfer of learning

Transfer is a core concept in education, aiming to enable students to apply knowledge in new contexts (Perkins & Salomon, 1992).

Cognitive psychology explores transfer through cognitive structure, production, and cognitive strategy theories. Ausubel's (1963) cognitive structure theory posits that new knowledge builds on existing mental frameworks, enhancing learning transfer. Modern cognitive psychology views declarative knowledge as stored in hierarchical propositional networks, affecting new knowledge acquisition (Zhu, 1999). Anderson's (1990) production transfer theory focuses on procedural knowledge, such as learning strategies. Productions—rules linking conditions and actions—determine skill transfer based on overlap between tasks (Singley & Anderson, 1989). The general consensus among researchers is that metacognitive strategies, as task-general, can be transferred (e.g., Schuster et al., 2020; Veenman & Verheij, 2003). Table 2 summarizes the support of various learning transfer theories for transferable content.

Table 2 Transfer Theory Foundation

Transferable content	Theory foundation
Subject matter knowledge	Cognitive structure transfer theory
Metacognitive strategies	Cognitive strategy transfer theory
Cognitive strategy application experience	Production transfer theory

The literature review integrates key theories – knowledge spiral, learning strategies, and GRR model – to develop a learning model that enhances the transfer learning ability of economics students in econometrics. Transfer theory supports the transfer of three types of transferable content

Conceptual Framework

This research is a study that develop a learning model and validate effectiveness of enhancing college students' transfer of learning through application test in econometrics. The researcher defines the research conceptual framework based on the knowledge spiral theory, cognitive and metacognitive strategies, the GRR model, and the theory of transfer of learning. The conceptual framework is as follows (see Fig. 2).

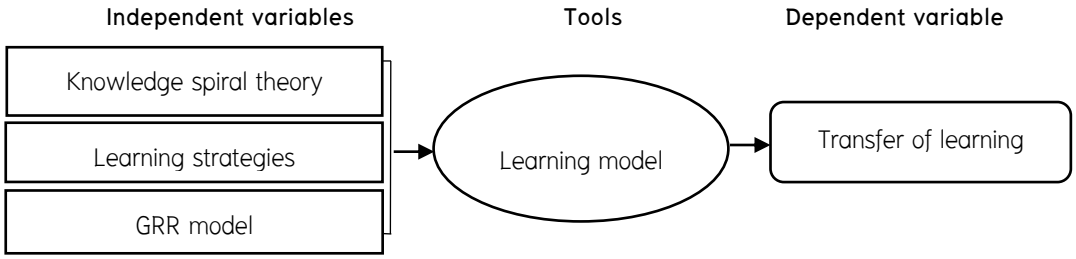

Fig.2 Conceptual Framework

Research Methodology

In this research, the independent variables are the learning model developed. The dependent variable is the college students' transfer of learning. The research process involves the following methodologies:

1. Population and Sample

The population includes 271 third-year students majoring in economics from six classes at Zhanjiang University of Science and Technology (Z University) in Guangdong Province, China, with approximately 45 students in each classroom.

The samples consist of two classes (89 students) of third-year students majoring in Economics from Z University. Two classes were randomly selected from the six classes using the cluster sampling method. One class is randomly assigned to an experimental group (44 students), using the GRR model, while the other classroom is a control group (45 students).

2. Method of developing the learning model

The steps for developing the learning model are as follows:

First, the learning content and objectives were determined, as outlined in the table 3.

Table 3 The Learning Content in Econometrics

Num	Content			Class
Unit 1	Simple linear regression model			9
Unit 2	Multiple linear regression model	Cognitive	Metacognitive	9
Unit 3	Dummy variable model	strategies	strategies	6
Unit 4	Model that relaxes basic assumptions			12
Unit 5	Time series econometric model			9

The learning objective of each unit is to understand knowledge and transfer it to problem–solving.

Second, a three–stage spiral structure was designed to align with learning content and objectives, based on knowledge spiral theory. Third, the learning method was determined using the GRR model and learning strategies. The GRR model transitions learning comprehension strategies from teacher–led to student–centered through four common teaching and learning steps. Fourth, integrating learning content, objectives, methods, and spiral structure, the final learning model aims to enhance students' knowledge understanding and address learning transfer issues. Fifth, the researcher submitted the model to an expert group of three specialists in econometrics and course research for review of its scientific validity and feasibility.

3. Method of developing evaluate instruments

After the teaching intervention, both the experimental and control groups took an application test that assessed knowledge understanding and problem–solving skills. Test scores reflected the students' level of knowledge comprehension and learning transfer.

4. Data Analysis Methods

The quantitative analysis is used to validate whether the experimental group's performance is higher than that of the control group. The qualitative analysis aimed to gain a deeper understanding of students' learning experiences, encompassing their learning sentiments and suggestions for teaching improvement.

Research Results

Objective 1. The results showed a Spiral GRR learning model developed by researcher. The learning model is as follow (see Fig.3).

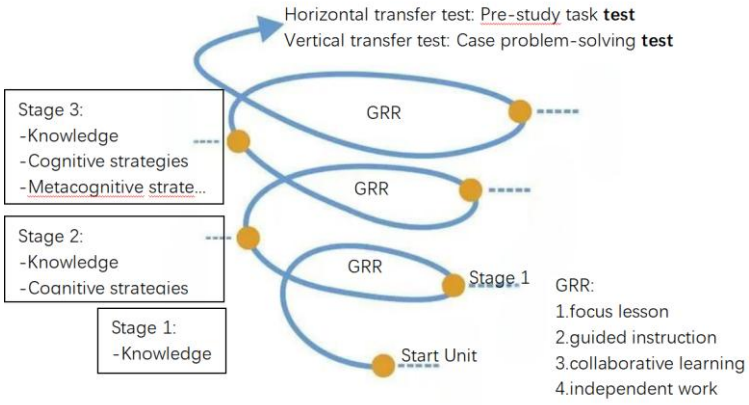

Fig.3 The Spiral GRR Learning Model

The learning process is divided into three stages,

1. Understand basic concepts and principles;

2. On the basis of understanding knowledge, learn and practice cognitive strategies, such as memorizing through loud or silent reading, using analogies and concept maps to elaborate, and organizing knowledge through summarization, creating tables, or using graphic organizers;

3. Obtain metacognitive strategies, such as self questioning, time management, monitoring one's own understanding and progress level, to promote students' self-directed learning.

Researcher implemented instruction based on the learning model for the experimental group students, intervening in their learning process. The control group students continued with traditional teaching methods. The textbook used was the fifth edition of "Econometrics" edited by Zi-Nai Li.

Objective 2. The results showed that the development of the evaluate instruments and the evaluate results.

The development of the evaluate instruments

The application test serves as a quantitative evaluation instrument, covering sections on knowledge understanding and the application for solving problems.

1) The knowledge understanding test covers univariate and multivariate linear regression models, parameter estimation, statistical significance testing, dummy variables, and their applications. It consists of 12 multiple-choice and 5 short-answer questions, totaling 100 points. Questions are drawn from past standardized tests and reviewed by three experienced Econometrics professors to ensure alignment with learning objectives.

2) The problem-solving section evaluates students' ability to apply knowledge through two case studies, each scored out of 100 points. Each case includes three sub-questions: identifying relevant concepts and methods, explaining the solution procedure, and performing Eviews operations with result analysis. This assesses students' learning transfer and practical application skills.

The interviews with students serving as a qualitative evaluation instrument. After the study of this unit, 5 students were randomly selected from the experimental group for interviews to investigate and analyze their learning experiences.

The evaluate results

The level of knowledge understanding between the experimental group and the control group are significantly different. The level of solving problems between the both group are also

significantly different. The control group, labeled as Group 1, comprises 45 students and the experimental group, labeled as Group 2, consists of 44 students.

1) A comparison of the knowledge understanding between the control group and the experimental group is presented.

From table 4, the homogeneity of variances between the control and experimental groups is tested. Table 2 indicates that F=0.075, P value=0.785, which is greater than 0.05, thus at the 5% level of significance, we do not reject H_0: equal variance assumed.

The difference of the means between the two groups is tested. Table 5 shows that the t-value is -2.894 and the P-value is 0.005, which is less than 0.05. Therefore, at the 5% level of significance, we reject the null hypothesis that there is no significant difference between the two groups, and we are 95% confident that the mean score of the experimental group is greater than that of the control group, with a difference falling within the interval (1.237, 6.664). This suggests that students' internalization and understanding of fundamental knowledge have improved after applying the learning model.

Table 4 Independent Samples Test of Knowledge Scores

	Levene's Test for Equality of Variances				**F**	**Sig.**
Knowledge	**(Equal variances assumed)**				**.075**	**.785**
Scores	t-test for	t	df	Sig.	95% Confidence Interval	
	Equality of Means				Lower	Upper
		-2.894	87	.005	-6.664	-1.237

2) A comparison of problem-solving scores between the control group and the experimental group is presented.

From table 5, the difference of the means between the two groups is tested. When t=-3.041 and P value=0.003, which is less than 0.05, at the 5% level of significance, the null hypothesis of equal means is rejected. This suggests that after applying the learning model developed by researcher, the ability of students to apply their acquired knowledge and experiment to solve problems has been improved, as well as their transfer of learning.

Table 5 Independent Samples Test of Transfer of Learning Scores

	Levene's Test for Equality of Variances				**F**	**Sig.**
Total	**(Equal variances assumed)**				**.200**	**.656**
Scores	t-test for	t	df	Sig.	95% Confidence Interval	
	Equality of Means				Lower	Upper
		-3.041	87	.003	-7.781	-1.630

In summary, the results reveal that the learning model not only developed the experimental group students' transfer of learning but also improved their scores on the fundamental knowledge test. This indicates that students are not only better at transferring knowledge, experiences, and strategies learned, but also at internalizing and understanding fundamental knowledge. It suggests that students have acquired strategies from their teachers, learned how to cognize knowledge, and developed metacognitive awareness. Additionally, the study also discovered that understanding knowledge can facilitate better transfer.

3) Interview Conclusions

Firstly, most students felt more comfortable with the new learning model, suggesting enhanced learning efficiency and engagement. Secondly, students reported being more conscious of applying learning techniques and paying greater attention to reviewing and reflecting on their learning process, indicating improved autonomous learning abilities.

Gender Differences: Interviews revealed that female students generally adapted better to the new learning model and reported higher learning efficiency. This may be linked to differences in cognitive processing and learning styles between genders.

Place of Birth Differences: Students from urban areas showed quicker adaptation to the new model compared to those from rural areas. This difference could be attributed to urban students' prior exposure to a wider variety of teaching technologies and methods.

Discussions

The econometrics curriculum in this study adopted a spiral adaptation of the Gradual Release of Responsibility (GRR) model, aligning with cognitive hierarchy and spiral learning theories. Structured into three instructional cycles—focusing on factual knowledge, cognitive skills, and metacognition—the curriculum allowed students to engage repeatedly

with content at progressively increasing levels of difficulty, fostering gradual skill development.

Our findings reflect Harden's (1999) observations on effective spiral curricula, which revisit topics at higher complexity levels, link new learning to prior knowledge, and enhance student capabilities. By revisiting key concepts more deeply, students built upon their existing knowledge, achieving a more comprehensive understanding of econometric principles.

Salomon and Perkins (1996) distinguish between low-road and high-road transfer, emphasizing strategic teaching for effective knowledge application. Our study found that the GRR model, particularly its emphasis on teacher guidance and metacognitive strategies, promoted high-road transfer. This deliberate form of transfer is crucial for applying econometric methods across diverse contexts.

Econometric content was chosen for its transferability and methodological significance in economic research. Using the GRR model enhanced students' ability to apply foundational methods and skills in various contexts. During the second semester of 2023, comparing the GRR model with traditional teaching revealed superior outcomes in learning transfer and problem-solving abilities.

The learning model focused on cognitive strategies and metacognition development, resulting in enhanced learning transfer and problem-solving performance. This aligns with Liu (2002) and Scharff et al. (2017), who stressed the importance of metacognitive reflection for flexible knowledge application. Teaching strategies included direct instruction, scaffolding, collaboration, and independent practice with diverse tasks, all contributing to improved future transfer performance.

Margolis (2020) and Aryal and Zollman (2007) advocate for scaffolding and peer interaction to construct new knowledge. Similarly, our study found these elements crucial for deep learning and effective knowledge transfer. Holladay and Quiñones (2003) and Schmidt and Bjork (1992) suggest varied practice can improve training transfer, and random variable practice enhances transfer performance. Our findings support these assertions, showing that the diversity of tasks within the GRR framework significantly boosted students' ability to transfer econometric knowledge.

In summary, the spiral GRR model, with its focus on gradually increasing knowledge complexity and integrating cognitive and metacognitive strategies, proved

effective in promoting learning transfer and problem-solving abilities in econometrics education. By fostering a deeper understanding of econometric principles and encouraging flexible knowledge application, this model offers valuable insights for improving pedagogical practices in specialized fields like econometrics.

Conclusion

The experimental group exhibited significantly enhanced outcomes compared to the control group, with improvements manifesting in two primary areas:

Firstly, students in the experimental group demonstrated a heightened capacity to internalize declarative and procedural knowledge. This improvement can be attributed to the acquisition of cognitive and metacognitive strategies that facilitated deeper understanding and retention.

Secondly, there was a marked enhancement in students' ability to transfer learning, as evidenced by their superior performance on application tests. This improvement stems from their enhanced comprehension and ability to establish connections between similar elements, allowing them to apply this knowledge and experience effectively in novel contexts.

These findings suggest that the acquisition of cognitive and metacognitive strategies plays a crucial role in fostering a deeper understanding of knowledge structures and promoting effective learning transfer. The spiral adaptation of the Gradual Release of Responsibility (GRR) model appears to be particularly effective in achieving these outcomes.

Suggestions

This study explored the effects of a learning model based on the spiral structure, learning strategies, and GRR on enhancing students' transfer of learning. While the model has shown promising results in the context of an econometrics course, further research is needed to validate its applicability and effectiveness across other methodology courses with similar characteristics. Expanding the scope of this research could accumulate more empirical evidence and broaden our understanding of its potential impact.

Moreover, instructional activities designed based on this learning model can be further optimized under the guidance of more experts. Collaborative efforts involving educators, cognitive scientists, and curriculum developers can refine the model to better suit diverse educational

environments and student needs. Future studies should also explore long-term impacts and adaptability of the model to different educational settings and disciplines.

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