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Active learning in authentic conditions has a positive effect on first-year student success

Manuel Bächtold[a,b], Dominique Barbe Asensio[a], Jacqueline Papet[a,b], and Appolinaire Ngoua Ondo[a]

[a]*OTP, SCSIP, University of Montpellier, France*
[b]*LIRDEF, University of Montpellier & University Paul Valéry Montpellier, France*

A number of studies, both in science education and in the humanities and social sciences, have shown that active learning has a more positive effect on student performance than direct instruction. As these studies were experimental or quasi-experimental, they compared ideal interventions designed and controlled by researchers. The present study aimed to measure the effects of active learning on student success under authentic conditions, by examining ordinary teaching practices that take place in real-life situations and are subject to various material, time-related and human constraints, which can affect teaching preparation and implementation. The study also investigated whether these effects depend on students' psycho-cognitive profiles. Data were collected from 356 teachers and 2168 students across various science and humanities programmes. The findings show that active learning under authentic conditions has a more positive effect on students' success in the first year of university than direct instruction. More specifically, they show that success is fostered when teachers adapt content to students' difficulties, use different active learning methods and in particular flipped classrooms, and use digital tools to engage students in activities. The results also show that active learning is equally beneficial for all students, regardless of their psycho-cognitive profile.

Keywords: teaching practices; active learning; academic success; approach to learning; motivation; epistemic beliefs.

1. Introduction

Active learning has been heavily promoted in higher education in recent years by many international organisations (Hartikainen et al., 2019). Teachers, it is claimed, should change their pedagogical practices by incorporating this teaching method increasingly. This can be justified by a body of research, both in science education and in the humanities and social sciences, which has shown that active learning has a more positive effect on student performance than direct instruction (Freeman et al., 2014; Kozanitis and Nenciovici, 2023). These studies are based on protocols that allow the conditions to be controlled, but which at the same time imply a modification of teachers' ordinary practices. They therefore provide results on ideal teaching practices. This raises the question of extrapolating the results to the context of authentic practices. When teachers incorporate active learning into their practices under institutional impetus, do they obtain the positive effects observed in controlled conditions? The aim of this study is to explore this question by comparing the effects on student success of active learning and direct instruction under realistic conditions.

2. Active learning: definition and teaching practices

While the term "active learning" obviously refers to students and their learning (Martella et al., 2024), it is commonly used to refer to specific teaching practices. It can be defined as a set of teaching practices involving students in activities which stimulate their engagement and thus promote learning of the content targeted by the teaching (Bächtold et al., 2024). Researchers also call these teaching practices "learning-centred approaches" (Postareff et al., 2008; Uiboleht et al., 2016) or "student-centred approaches" (Coorey, 2016). Active learning encompasses several specific teaching methods such as problem-based teaching, project-based teaching, inquiry-based teaching, flipped classrooms and cooperative learning (Crouch & Mazur, 2001; Kozanitis & Nenciovici, 2023). To some extent, these teaching methods overlap. For instance, project-based and inquiry-based teaching generally involve solving a problem and are often conducted in small groups to encourage cooperation among students (Savery, 2006). All of these teaching methods engage students in activities that eventually lead them to be more cognitively active when they learn and use the content being taught. Active learning can be seen as belonging to the constructivist paradigm of teaching and learning (Bächtold, 2013). It is assumed that this cognitive activity enables students to partially reconstruct the knowledge they are attempting to acquire on the basis of their prior conceptions (Hartikainen et al., 2019; Uiboleht et al., 2016). In other words, active learning is by no means reducible to the behavioural activity that can be observed when students handle instruments or produce something. This behavioural activity should be seen above all as supporting cognitive activity, which is essential for learning (Mayer, 2009). In addition, this behavioural activity also promotes the development of skills associated with certain practices, such as the abilities to cooperate, communicate and solve problems (Børte et al., 2023; Hartikainen et al., 2019; White et al., 2015). Active learning has also been defined in opposition to direct instruction. The latter refers to a set of teaching practices that are content- and teacher-centred, consisting of teachers directly transmitting content to students without any detours through activities to be carried out by the students themselves (Coorey, 2016; Postareff et al., 2008; Uiboleht et al., 2016).

To illustrate how active learning can be implemented in higher education, let us consider two concrete examples. The first example involves problem-based teaching. In a third-year biomedical engineering course, for instance, students could be presented with complex clinical scenarios requiring diagnosis and treatment planning. Working in small groups, they could identify learning objectives, research relevant concepts and then reconvene to propose evidence-based solutions. The teacher would facilitate reflection and synthesis. The second example uses project-based teaching. In a master's-level environmental science course, students could collaborate over several weeks to design a sustainable urban drainage system for a local municipality. The project might involve stakeholder interviews, technical modelling and a final presentation to city planners.

Some studies have found only a weak presence of active learning methods in the teaching practices of teachers in higher education, which are more akin to direct instruction (Børte et al., 2023; Lillejord et al., 2018). However, other studies have shown that few teachers systematically practise direct instruction (Bächtold et al., 2024; Postareff et al., 2008; Stes et al., 2014). These studies highlight the complexity of teaching practices, which most often intertwine active learning and direct instruction. Such dissonances in teaching practices have been identified both between different aspects of a teacher's teaching practices (e.g. the preparation or implementation of a lesson) and within the same aspect of these practices (e.g. during the preparation of a lesson) (Uiboleht et al., 2016).

3. Previous research on the impact of active learning on student success

A number of studies have found that active learning methods are more effective than direct instruction in promoting student learning, both in the context of science education and in the humanities and social sciences. Freeman and colleagues (2014) conducted a meta-analysis of 225 studies investigating student exam scores or failure rates in science, technology, engineering and mathematics (STEM) courses, comparing active learning and traditional lecturing conditions. The studies selected were experimental or quasi-experimental studies comparing two groups of students, one exposed to an active learning method and the other exposed to traditional lecturing. The active learning interventions under consideration included a variety of pedagogical methods such as occasional group work, problem solving, worksheets or tutorials completed in class, the use of personal response systems with or without peer instruction, and studio or workshop course designs. The results showed that active learning improves student performance across STEM disciplines. The difference was calculated as the standardised mean difference, i.e. the difference between the mean scores of the two groups divided by the pooled standard deviation. Performance was found to be higher by 0.47 standard deviations under active learning, compared to traditional lecturing. This difference can be interpreted as a large effect (Kraft, 2020). The results indicated also that average exam scores improved by around 6% in active learning courses and that, on average, students in traditional lecture courses were 1.5 times more likely to fail than students in active learning courses. The benefits of active learning were found in all class sizes, whether small (<50 students), medium (51-110 students) or large (>110 students), with a significantly more positive effect for small class sizes. No statistically significant difference was found in terms of course type and course level, i.e. when comparing courses for majors and non-majors, or introductory and upper-division courses.

More recently, Kozanitis and Nenciovici (2023) conducted a similar meta-analysis of 104 studies comparing the effect of traditional lecturing and active learning on the performance of undergraduate students in humanities and social science programmes. The studies selected were also experimental or quasi-experimental. A variety of teaching methods were included under the umbrella of active learning. Those most frequently considered in the selected studies were problem-based learning, project-based learning, clicker (classroom or personal response system), flipped or inverted classroom, computer simulation or serious game, peer-based, team-based or collaborative learning. The results were similar to those of the previous mentioned meta-analysis. Performance was found to be higher by 0.49 standard deviations under active learning, which again can be interpreted as a large effect (Kraft, 2020). The results also showed a significantly higher effect of active learning for the smallest class sizes (<20 students). However, in contrast to the meta-analysis in the STEM context, the level of the course was found to have a modulating effect, with a higher effect for upper level compared to introductory level. Furthermore, the effect of active learning was found to be higher for some subject matters (e.g. sociology and psychology) than for others (e.g. history and management).

Research has shown that students generally have a positive perception of active learning methods (Andrews et al., 2022). However, studies have shown that some students may exhibit resistance to certain active learning methods, particularly cooperative activities involving interaction with other students (Bächtold et al., 2023; Machemer & Crawford, 2007). One study also revealed apparently paradoxical results concerning measured learning gains and students' perception of learning (Deslauriers et al., 2019). The results of this study showed that students exposed to active learning had better learning achievements than students exposed to lecturing, but rated the quality of teaching less highly and had a less positive perception of their learning in the case of active learning. According to the authors of this study, students usually experience increased cognitive effort in active learning classrooms and tend to associate this effort with poorer learning. In the light of these studies, we might wonder whether students' perceptions of active learning courses, and consequently their involvement in these courses and the actual learning gains, do not vary according to the profile of the students, in particular according to their psycho-cognitive profile. This profile may include several dimensions such as motivation approach to learning, and epistemic beliefs (Papet et al., 2025). To the best of our knowledge, very little, if any, research has been undertaken on this issue.

4. Rationale and research questions

In order to compare the effects of active learning and direct instruction on student performance, the previous studies mentioned above were based on an experimental or quasi-experimental design, i.e. they used controlled conditions procedures. The advantage of these studies is that they are able to measure the effect of one variable (in this case, the teaching method) while keeping the other parameters (e.g. discipline, course, year of study, initial level of the students, etc.) unchanged. However, their disadvantage is that they require researchers to intervene in teachers' actual practices. They create conditions that are to some extent artificial and deviate from the real world. Consequently, the results available on the positive effects of active learning relate more to ideal teaching practices than to actual teaching practices. The first aim of the present study was to address this issue and to compare the effects on student success of active learning and direct instruction under authentic conditions, by examining ordinary teaching practices that are not piloted or biased by researchers. The second aim was to measure these effects according to the psycho-cognitive profile of the students, in order to determine whether active learning benefits to all students or only certain students. This study focused on the first year of university and was carried out at a university in France. The two research questions investigated were:

- RQ1: Can we observe a difference between the effects of active learning and the effects of direct instruction under authentic conditions on the success of first-year students?
- RQ2: Do the effects of active learning and direct instruction depend on the psycho-cognitive profile of the students?

5. Method

5.1 Methodological procedure

Comparing the effects of active learning and direct instruction under authentic conditions requires an alternative methodology to controlled experimentation, which would impose idealized conditions. This study uses a methodology based on collecting and analysing data from two questionnaires. The first was administered to teachers to characterize their teaching practices, with an effort to account for their potential complexity and avoid reducing them prematurely to a binary opposition between active learning and direct instruction. The second was administered to students, whose exam results were known, in order to identify their psycho-cognitive profiles and examine the extent to which the effects of different pedagogical approaches are modulated by these profiles. To enable the analysis of links between these two datasets, we selected course units for which teaching practices could be described with sufficient granularity and for which student exam performance was available. The analysis of relationships between these data was conducted using two complementary methods: correlation analysis, to identify pairwise relationships, and principal component analysis (PCA), to explore these relationships holistically.

5.2 Participants

The participants in this study were 356 teachers and 2168 first-year students at a French university. These participants were respectively teaching and studying in the first year of an undergraduate programme in science and/or the humanities. Ten different educational programmes were concerned, each from a different faculty: the faculties of Economics, Education, Engineering, Law and Political Science, Management, Physical Activity and Sport, Science, and three faculties of Technology. 44.7% of the teachers were women and 55.3% men. 25.8% had less than 7 years' teaching experience, 35.1% between 7 and 18 years, and 39.1% more than 18 years. 58.9% of the students were women and 41.1% men. The students had a mean age of 18.57 years (*SD* = 1.70). 58.9% of the students were women and 41.1% men. Ethical approval for the study was obtained from the Research Ethics Committee of the University of Montpellier (number UM 2023-035), and all participants provided informed consent. The recruitment strategy aimed to include a wide range of teaching contexts and student profiles, thereby supporting diverse inclusion and minimizing the risk of artificial homogeneity within the sample. Participants were recruited from existing course units with no experimental manipulation, in order to reflect authentic teaching and learning conditions.

5.3 Teacher-related data collection and analysis

Data regarding teachers were collected through a questionnaire administered electronically. This was an exploratory questionnaire consisting of 56 items (see Supplemental materials A), designed to capture as accurately as possible authentic teaching practices. Teachers were asked to consider the course they were giving in a pre-identified teaching unit within a first-year training programme and to respond on a 7-point Likert scale. The questions were designed to provide a detailed characterisation of teaching practices in three different areas: preparation of teaching, implementation of teaching and use of technology for teaching. These questions were developed by three researchers, two of whom are also lecturers in different faculties at the university. To ensure the content validity of the items, i.e. their relevance within the institutional context and clarity of meaning, cognitive interviews were conducted with two members of the pedagogy training service, two members of the digital pedagogy support team, and five lecturers from various faculties across the university. This process helped to refine the wording of the questions and ensure that they would be well understood by potential respondents, while also reflecting the diversity of teaching contexts within the institution. To reduce the items to a limited number of measures, an Exploratory Factor Analysis (EFA) was performed, resulting in the construction of 18 measures. The preparation of teaching measures were as follows: *Based on expertise in the discipline* (1 item), *Use of university textbooks* (1 item), *Use of history or epistemology of the discipline* (1 item), *Use of a national reference framework of knowledge and/or skills* (1 item), *Use of the university reference framework of knowledge and/or skills* (1 item), *Content adaptation to students' difficulties* (2 items, McDonald's ω = .69), *Sharing with colleagues* (7 items, ω = .93), *Use of teaching resources* (1 item). The implementation of teaching measures were the following: *Teacher content delivery followed by students application* (2 items, ω = .76), *Students cooperative, critical, self-reflective and/or discovery activities* (7 items, ω = .88), *Active learning methods (i.e., problem-based, project-based,* *inquiry-based teaching, cooperative learning, and interdisciplinary approach)* (5 items, $\omega = .76$), *Flipped classrooms* (1 item), *Serious games* (1 item), *Active learning methods considered beneficial* (10 items, $\omega = .97$). Note that the EFA led us to separate the items associated with flipped classrooms and serious games, which can be considered as active learning methods, from the other items associated with active learning methods. The use of technology for teaching measures were as follows: *Importance of digital tools in the teaching process* (1 item), *Digital tools for content delivery, distance support, and motivation* (5 items, $\omega = .91$), *Digital tools for collaboration, debate, assessment, and digital training* (4 items, $\omega = .79$), *Digital tools for students producing new content* (1 item).

In a previous study, we used a clustering method to identify profiles of practices in each teaching area (Bächtold et al., 2024). Several clustering algorithms were compared to optimise groups formation (using Connectivity, Dunn and Silhouette indices). Different groups could be distinguished for each teaching area (details are given in Supplementary Material B). Concerning teaching preparation, three groups could be distinguished (using HAC) with the following main characteristics:

- Prep_G1 ($N = 123$): teachers who adapt the content least to the students and base their teaching least on academic textbooks and on the history or epistemology of the discipline;
- Prep_G2 ($N = 81$): teachers who rely the least on university or national reference frameworks;
- Prep_G3 ($N = 152$): teachers who rely the most on teaching resources and academic textbooks, adapt the most the content to the students and base it the most on the history or epistemology of the discipline;

Being students-centred, Prep_G3 is in line with active learning methods, in contrast to Prep_G1 which is in line with direct instruction.

In terms of teaching implementation, four groups could be distinguished (using DBSCAN) with the following main characteristics:

- Impl_G1 (*N* = 183): teachers who implement the least flipped classroom and other active learning methods;
- Impl_G2 (*N* = 96): teachers who implement the most flipped classrooms;
- Impl_G3 (*N* = 59): teachers who see the most benefit in implementing active learning methods;
- Impl_G4 (*N* = 18): teachers who make the most use of serious games and active learning methods.

Impl_G2, Impl_G3 and Impl_G4 are three different groups in line with active learning methods, in contrast to Impl_G1 which is consistent with direct instruction.

Regarding the use of technology for teaching, three groups could be distinguished (using DBSCAN) with the following main characteristics:

- Tech_G1 (*N* = 80): teachers who make the least use of digital tools;
- Tech_G2 (*N* = 171): teachers who make the most use of digital tools, both to get students to carry out activities and to deliver content;
- Tech_G3 (*N* = 105): teachers who use digital tools to deliver content above average.

By focusing on student activities, Tech_G2 is aligned with active learning methods, in contrast to Tech_G3, which is aligned with direct instruction.

5.4 Student-related data collection and analysis

Data regarding students were partly provided by the university administration and partly collected through a questionnaire. The university administration provided demographic data on the students (age, gender) and the average marks they obtained in each teaching unit of their educational programme in the first semester. A minimum average mark of 10 out of 20 was required to validate a teaching unit. In this study, student success was measured in terms of the validation of teaching units, rather than on the basis of standardised tests designed by researchers. This choice is consistent with taking into account ordinary teaching practices, which include ordinary assessment methods. The questionnaire allowed to collect data on psycho-cognitive characteristics of the students. It was administered electronically to students two months after the start of their first year of study and consisted of 45 closed-ended questions (see Supplemental materials C). Some of the questions were adapted from existing literature, while others were developed by our research team. The wording of the questions was refined following a qualitative pre-test involving interviews with five students, as well as three successive pilot tests conducted with a total of 980 students. For all the items, students were asked to respond on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The items were used to construct five psycho-cognitive variables. Three variables related to motivation as defined by Ratelle et al. (2007) within the self-determination theory (Ryan and Deci 2000): *self-determined motivation*, consisting of 16 items ($\omega = .92$) measuring autonomous regulation (i.e., acting out of choice and pleasure) ; *controlled motivation*, consisting of 8 items ($\omega = .83$) measuring controlled regulation (i.e., acting for reward, behaving to avoid punishment, or trying to avoid feelings of guilt); and *amotivation* consisting of 4 items ($\omega = .86$) measuring lack of motivation and resignation. The fourth variable considered was *deep approach to learning*, which was conceived in line with Nelson Laird et al.'s (2008) characterization and constructed by means of 13 items ($\omega = .87$) measuring the extent to which students demonstrate cognitive engagement with learning tasks by trying to relate the different content of knowledge being taught, reflecting on their learning, and interacting with peers and teachers to better understand what is being taught. The fifth variable was *evaluative epistemic beliefs*, which consisted of 4 items ($\omega = .62$) measuring the extent to which students have a sophisticated view of the nature of knowledge and the process of knowing, taking into account the four types of beliefs distinguished by Hofer and Pintrich (1997) in terms of uncertainty, complexity, source and justification. The relatively low reliability value for this variable is not unusual (Schiefer et al., 2022) and can be explained by the more or less consistent system of epistemic beliefs adopted by individuals (Schommer, 1990).

In previous studies, we have shown that motivation, approach to learning and epistemic beliefs are related (Bächtold et al., 2023, 2025) and that they make it possible to characterise different psycho-cognitive profiles (Papet et al., 2025). Again, several clustering algorithms were compared. Five psycho-cognitive profiles were identified (using PAM), the main characteristics of which are as follows (details are given in Supplementary Material D):

- Academic ($N = 573$): students with the highest self-determined and controlled motivation, the deepest approach to learning, and the most evaluative epistemic beliefs;
- School-like ($N = 531$): students who, compared to the average, have higher controlled motivation;
- Curious ($N = 415$): students who, compared to the average, have higher self-determined motivation and lower controlled motivation, a deeper approach to learning and more evaluative epistemic beliefs;
- Uninspired ($N = 394$): students with the lowest self-determined and controlled motivation, but not high amotivation, the least deep approach to learning, and the least evaluative epistemic beliefs;
- Resigned ($N = 255$): students with by far the highest amotivation.

5.5 Data processing and statistical analyses

A total of 100 teaching units were considered in the study. Depending on the unit, between 1 and 29 teachers were involved in the teaching sessions (with an average of 8.29 teachers per unit). The teaching practices of each unit were characterised on the basis of the declared practices of the teachers who completed the questionnaire. 42.0% of the teachers involved in these 100 units involved in these 100 units responded to the questionnaire, i.e. 356 teachers. The average response rate per teaching unit was 51.6%. To characterise the teaching practices of a unit, we distinguished between preparation of teaching, implementation of teaching and use of technology for teaching. For each teaching area, we considered the proportion of teachers in each of the groups of practices described above. For example, for the preparation of teaching, we considered the proportions of teachers in the Prep_G1, Prep_G2 and Prep_G3 groups. The students in the study were all assessed in one or more of these 100 teaching units, so they either succeeded or failed in these units. The success rate of students in each unit could thus be linked to the teaching practices in that unit. ~~We calculated the correlations between the different teaching practices and student success. We also performed a principal component analysis (PCA) to reduce the data and visually identify the links between all the variables considered together.~~ We calculated the correlations between the different teaching practices and student success to explore pairwise relationships. We also performed a PCA, which provides a more nuanced and integrative view of the data. Unlike simple correlations, PCA considers all variables simultaneously and reduces dimensionality by identifying latent structures that explain the most variance. This allows us to visualize and interpret the complex interdependencies between teaching practices and student outcomes in a more holistic way.

6. Results

6.1. Effects of active learning on the success of first-year students (RQ1)

To measure the effects of the different teaching practices on student success in the first year of university, we first calculated the Spearman correlations between, on the one hand, the success rate of students in the different teaching units considered and, on the other hand, the proportion of the different teaching practices used in these same units. The results are reported in Table 1. Concerning the preparation of teaching, the success rate is positively correlated with Prep_G3 (0.419), which is in line with active learning methods, as teachers in this group are the ones who adapt the content most to try to overcome students' difficulties. It is also negatively correlated with Prep_G2 (– 0.469), which gathers teachers who rely less than others on university or national reference frameworks. In both cases, the correlation coefficient is above 0.3, so the effect size can be considered large (Gignac & Szodorai, 2016).

In terms of teaching implementation, the success rate is positively correlated with Impl_G3 (0.305), which aligns with active learning methods, as this group consists of teachers who see the most benefit in implementing active learning methods (such as project-based, problem-based, or inquiry-based teaching). It is negatively correlated with Impl_G1 (– 0.347), which brings together teachers who apply less than others flipped classrooms and other active learning methods. Again, in both cases, the effect size can be considered large.

Regarding the use of technology for teaching, the success rate is positively correlated with Tech_G2 (0.467), in line with active learning methods, as teachers in this group are the ones who make the most use of digital tools to engage students in activities. The effect size in this case is large. The success rate is also negatively correlated with both Tech_G1 (– 0.300), which includes teachers who use digital tools the least, and Tech_G3 (– 0.253), which is in line with direct instruction, as this group consists of teachers who use digital tools to deliver content more than average. The effect size of these negative correlations is medium.

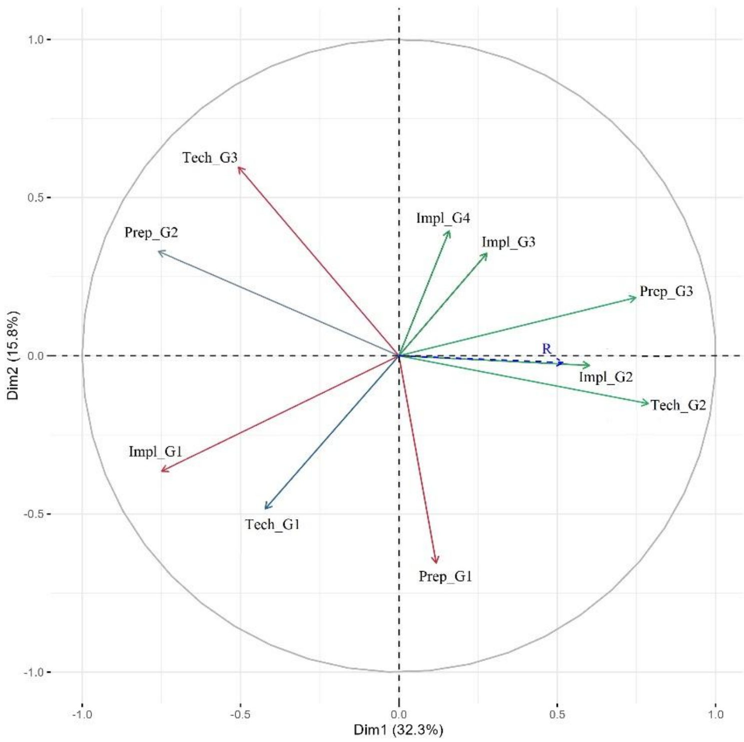
Table 1. Correlations (Spearman's rho) between the rate of success of all students and the teaching practices.

Variables			**Spearman's *rho***		***p***
Rate_of_Success	-	Prep_G1 (Direct instruction)	0.073		0.469
	-	Prep_G2 (NA)	− 0.469	***	< .001
	-	Prep_G3 (Active learning)	0.419	***	< .001
	-	Impl_G1 (Direct instruction)	− 0.347	***	< .001
	-	Impl_G2 (Active learning)	0.165		0.102
	-	Impl_G3 (Active learning)	0.305	**	0.002
	-	Impl_G4 (Active learning)	0.135		0.180
	-	Tech_G1 (NA)	− 0.300	**	0.002
	-	Tech_G2 (Active learning)	0.467	***	< .001
	-	Tech_G3 (Direct instruction)	− 0.253	*	0.011

* $p < .05$, ** $p < .01$, *** $p < .001$

To investigate the effects of the different teaching practices on student success, a PCA was also conducted. Figure 1 displays the first two dimensions (which explain 48.1% of the variance). The blue arrow R represents the rate of success. The green arrows represent the different teaching practices associated with active learning methods, the red arrows represent those associated with direct instruction, and the grey arrows represent those that are not associated with either of these two approaches. The criteria used to interpret the figure are as follows: the longer an arrow is in the PCA plane, the higher the quality of representation of the variable in this plane; the more two arrows tend to point in the same direction or in the opposite direction, the more the two variables are correlated respectively in a positive or negative way; the more two arrows tend to point in perpendicular directions, the less the two variables are correlated. Based on these criteria, it emerges that the student success rate is positively correlated with mainly three teaching practices: preparation during which teachers take account of students' difficulties and adapt the content (Prep_3), the implementation of active learning methods and in particular flipped classrooms (Impl_2), and the use of digital tools to engage students in activities (Tech_G2). These are three teaching practices that belong to active learning methods. Conversely, the student success rate is negatively correlated with several teaching practices, particularly that of implementing teaching in accordance with a direct instruction approach (Impl_G1).

Figure 1. Rate of success (R) of all students and the different teaching practices represented on the first two dimensions of the PCA.

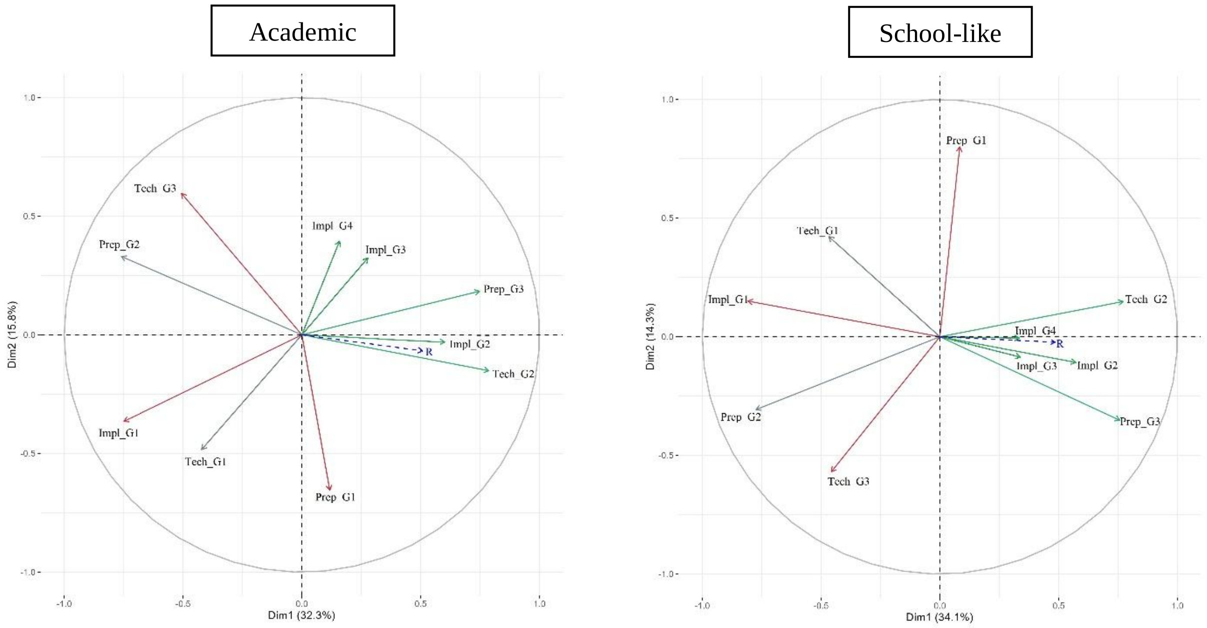


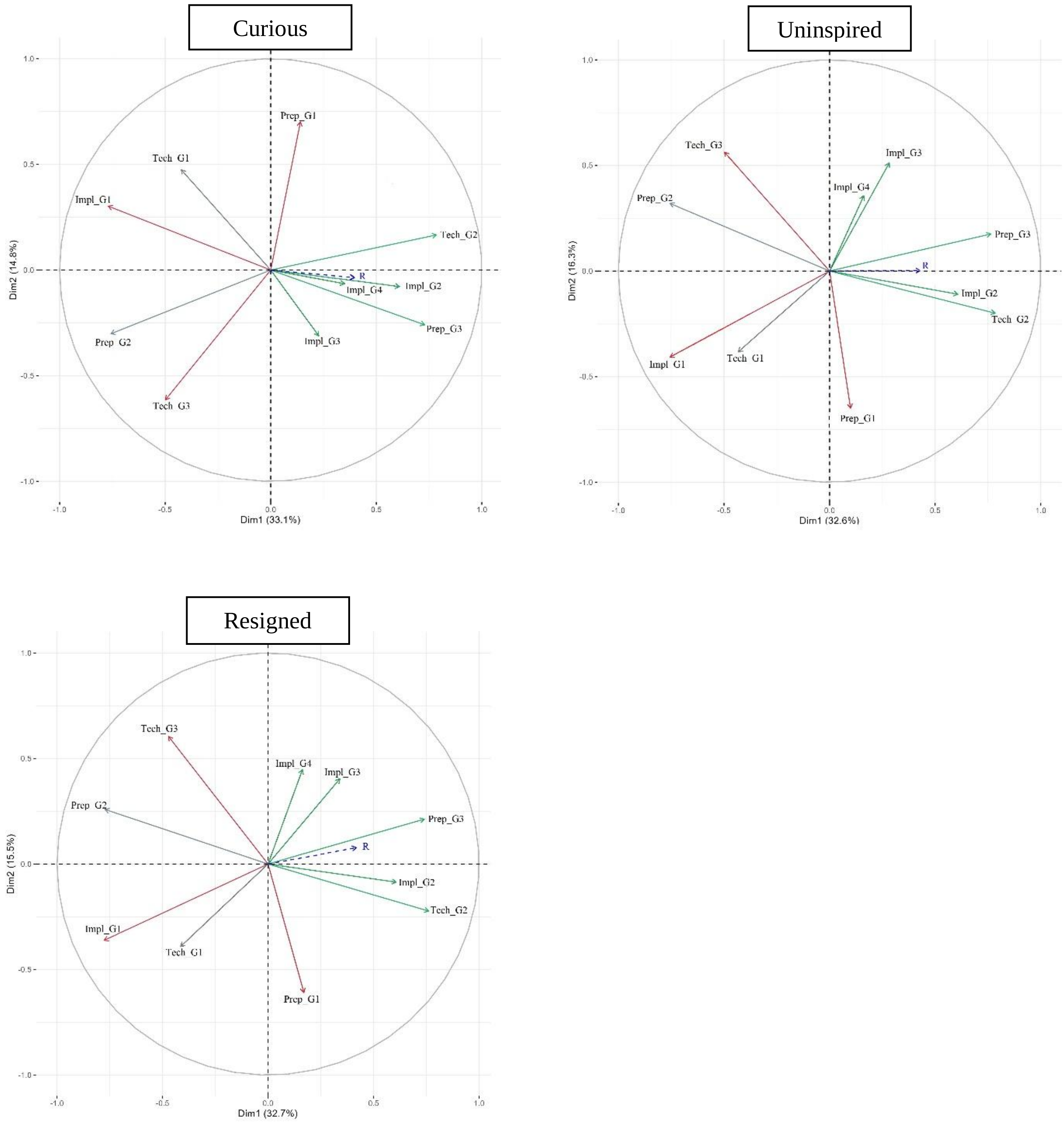
6.2. Effects of active learning according to student profile (RQ2)

To investigate whether the effects of active learning and direct instruction depend on the psycho-cognitive profile of the students, we calculated the Spearman correlations between the success rate for each student profile and the different teaching practices. The five profiles described above were considered: Academic, School-like, Curious, Uninspired, and Resigned. The correlations obtained are similar in terms of significance and order of magnitude for the five profiles (see Supplemental Materials E), with one exception: Tech_G3 (which is in line with direct instruction) is significantly correlated only with the success rate of students in the Academic profile. A Fisher's Z-test was performed for comparing the correlation coefficients. No differences, including those concerning Tech_G3, were significant (see Supplemental Materials E).

To further investigate the dependence on student profile of the effects of the different teaching practices, a PCA was performed for each profile. Figure 2 shows the first two dimensions of each PCA. Apart from some small differences, the patterns are all similar and provide a robust result: for each profile, the student success rate is positively correlated mainly with the three teaching practices mentioned above (i.e., Prep_G3, Impl_G2 and Tech_G2), all of which are in line with active learning methods.

Figure 2. Rate of success (R) of the students according to their profile and the different teaching practices represented on the first two dimensions of the PCA.





7. Discussion

This study extends previous research (Deslauriers et al., 2019; Freeman et al., 2014; Kozanitis & Nenciovici, 2023) aimed at assessing the effects of active learning methods, compared to direct instruction, on student success at university. It differs from previous studies in that it explores the effects of teaching practices under authentic conditions, rather than the effects of ideal interventions designed and controlled by researchers. In more precise terms, the first research question was whether there is a difference between the effects of active learning and the effects of direct instruction under authentic conditions on the success of first-year students (RQ1). The results suggest that there is. They show that active learning methods have a more positive effect on student success in the first year of university than direct instruction. More specifically, they show that success is fostered by teaching practices that combine (*a*) preparation during which teachers take account of students' difficulties and adapt content accordingly, (*b*) the implementation of active learning methods and in particular flipped classrooms, and (*c*) the use of digital tools to engage students in activities. In the three teaching areas examined in this study (i.e. preparation of teaching, implementation of teaching and use of technology for teaching), the practices related to active learning methods all have a large positive impact (following the guidelines of Gignac & Szodorai, 2016) on the success of first-year university students.

These results are in line with previous studies conducted under controlled conditions (Deslauriers et al., 2019; Freeman et al., 2014; Kozanitis & Nenciovici, 2023). They challenge the objection that the active learning methods tested in these studies correspond to ideal interventions, i.e. those designed by researchers and implemented under their control. The present study concerns teaching practices reported by teachers when they are in authentic conditions, i.e. when they are faced with all the constraints and limitations that can alter the preparation and implementation of teaching, such as material constraints (spatial design or available equipment), time constraints (related to teachers' workload or work context), human constraints (lack of support from the teaching team or students' refusal to carry out tasks) or limitations in terms of teaching expertise (lack of pedagogical training or limited teaching experience) (Børte et al., 2023). The results of this study show that even in the face of all these possible constraints and limitations, which are part of teachers' real lives, active learning has a more positive effect on student success than direct instruction, in undergraduate learning situations.

Previous research has shown that students may experience increased cognitive effort and poorer learning in the context of active learning methods (Deslauriers et al., 2019). This suggests that some students may be more or less receptive to these methods. The present study also aimed to investigate whether the effects of active learning and direct instruction depend on the psycho-cognitive profile of the students (RQ2). Five profiles could be distinguished from the students' data: Academic, School-like, Curious, Uninspired, and Resigned. We might assume that the Academic and Curious students, with higher self-determined motivation, deeper approach to learning and more evaluative epistemic beliefs compared to average, would be more receptive to active learning methods than the Uninspired and Resigned students, and that consequently these methods would be more or only beneficial to the success of the former. However, the findings show that active learning methods used in the three teaching areas examined in this study (i.e. preparation of teaching, implementation of teaching and use of technology for teaching) are equally beneficial to all students. Whatever their psycho-cognitive profile, active learning methods have a more positive effect on student success than direct instruction.

8. Educational implications

This study has several important implications regarding the use of active learning in higher education. Teachers may be reluctant to change their teaching practices and adopt more active learning methods due to the time and investment required, the additional workload this would entail, and their lack of specific skills in this area. They may also fear that students will resist active learning (Tharayil et al., 2018). However, the results show that, when used in realistic conditions, active learning methods benefit the success of all students, regardless of their psycho-cognitive profile, that is, the way in which they engage with learning tasks. Therefore, this study provides academic managers and teachers with empirical evidence to encourage the adoption of these methods in university teaching practices from the first year onwards.

These recommendations do not imply the exclusive use of active learning methods. In fact, the teachers in the study used these methods to very different extents. They may be more or less adapted depending on the objectives in terms of knowledge acquisition and skills development. They may be more appropriate for exploring in depth content that is open to multiple interpretations or misconceptions, whereas direct instruction may be more appropriate for learning factual content. Moreover, when combined, active learning and direct instruction can be mutually beneficial: when direct instruction precedes active learning sessions, it can provide students with the necessary prior knowledge, and conversely, active learning sessions can help prepare students for learning through direct instruction.

In line with previous research, this study shows that the cognitive activity stimulated by active learning methods promotes academic success among students. This finding is important to consider in light of the growing use of generative AI by students, which can increase their agency but also presents the risk of making them passive in their approach to learning (Yang et al., 2024). Ways of integrating generative AI into active learning methods therefore deserve close attention today.

9. Limitations and future directions

There are several limitations to this study. Some of them lie in the methodology. The measures of teaching practices were constructed on the basis of an exploratory questionnaire with numerous items aimed at capturing as accurately as possible authentic teaching practices. The EFA carried out to reduce the items to a limited number of measures resulted in some measures based on several items (all characterised by McDonald’s omegas above 0.69, which indicates their good reliability), but also in some measures based on a single item, which makes them less robust in terms of reliability. In order to consolidate or qualify the results of the study, it should be replicated using only measures based on several items with appropriate reliability coefficients.

The study is based on the reported practices of teachers involved in a set of teaching units. The average response rate per unit was 51.6%. The partial nature of the data raises a problem at the level of the teaching units when they are considered individually. If the practices described by the teachers involved in a unit are not representative of the practices of all the teachers involved in that unit, this constitutes an uncontrolled bias. However, given the large number of units considered ($N = 100$) and the large number of teachers who responded ($N = 356$), we can assume that this bias is neutralised. The greater the number of teaching units considered, the greater the likelihood that the biases specific to each teaching unit will cancel each other out.

There are also limitations relating to the scope of the results. This study was carried out in the first year of university. It is therefore possible that the results obtained may not be the same at higher course levels. However, previous studies have shown that in the context of humanities and social sciences education, but not in science, the effect of active learning methods is modulated by course level, with a greater effect at higher levels than at introductory levels (Freeman et al., 2014; Kozanitis & Nenciovici, 2023). Presumably the same is true under authentic conditions. At least, these studies suggest that the benefits of active learning methods compared to direct instruction in authentic conditions are no less at higher course levels. But this remains to be investigated. The data from the study were also insufficient in terms of statistical power to compare the effects of teaching practices according to discipline (humanities and social sciences versus sciences) or according to class size. New, larger-scale studies could also be carried out to investigate the influence of these three factors.

Several active learning methods were considered in the study: problem-based, project-based and inquiry-based teaching, cooperative learning, interdisciplinary approach, flipped classrooms, and serious games. The question arises as to whether one of these methods is more conducive to student success than the others. The meta-analysis by Kozanitis and Nenciovici (2023) shows that under controlled conditions there is no significant difference between several of these methods, particularly between problem-based and project-based teaching, cooperative learning and flipped classrooms. In our study, the analysis of the relationships between teaching practices and student success rates using PCA seems to favour flipped classrooms. However, the construction of the measures in our study does not allow all teaching methods to be compared, as we conducted an EFA that resulted in several of these methods (i.e., problem-based, project-based and inquiry-based teaching, cooperative learning, and interdisciplinary approach) being combined into a single measure (active learning methods). A systematic comparison of all these methods under authentic conditions shall be carried out. The difficulties to be overcome lie in the different ways in which these different methods are conceived and used by teachers, in the fact that they overlap to some extent (Savery, 2006), and also in the fact that teachers may use two or more active learning methods in the same teaching unit.

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