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Article

How Creativity in STEAM Modules Intervenes with Self-Efficacy and Motivation

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Abstract: Many current curricula, in going beyond traditional goals, increasingly foster creativity in science classrooms, declaring creativity a core skill of the 21st century. For enhancing creativity in science classrooms, the subject Arts is considered to offer a potential way from STEM (Science, Technology, Engineering, Mathematics) to STEAM (STEM with Arts)). The Horizont-2020 project Creations prepared more than 100 creativity-enhancing STEAM modules based on the 5E instructional model. STEM subjects were mathematics, biology, physics, chemistry or technology, and often interdisciplinary for different school and class levels between the ages of nine and nineteen. All modules provided a social environment fostering creativity where students imagine, explore, experiment, test, manipulate, and speculate. Exemplarily, five modules including physics, math, and biology, were selected, for monitoring motivation and creativity. The first was measured on the level of career-motivation and self-efficacy, the latter focused on two sub-constructs: active cognition such as idea processing (Act), and a mental state of creative immersion (Flow). Subjects were a sample of 995 students (9–18 years). In summary, no gender impact or age effect appeared in any of the monitored variables. Participation intervened with Self-Efficacy and Act, while Career Motivation or Flow did not. Act as a cognitive variable associated with creativity might be more sensitive to changes, whereas Flow as a parameter measuring a state of mind related to emotion appears more stable. Path analysis supported the role of creativity for Career-Motivation by promoting Self-Efficacy. Conclusions for appropriate educational settings to foster STEAM environments are discussed.

Keywords: creativity; self-efficacy; STEM education; STEAM (enriched with arts); inquiry-based science education; science classroom

1. Introduction

While in the 20th century the main research struggle was to define creativity appropriately [1], despite all the complexity of the construct, this is certain: creativity is a pivotal competence to solve current problems and to meet the requirements of the post-industrial age [2]: the young generation needs to rediscover creativity with its mental flexibility and joy to experiment. Therefore, some authors even declared creativity the 21st century's key skill and highlighted it as an essential educational goal [3]. Formerly, education was optimized for standardization and conformity, leading to compulsory curricula and strict testing requirements. Arts was reduced to a mere element of subject teaching, ignoring more or less the essence of creativity rather than using it as an element of learning across all classroom subjects [4]. Nowadays, counteracting this trend, curricula increasingly promote "ability" (competence orientation) instead of the traditional transfer of "knowledge" (cognition) [5].

1.1. From STEM to STEAM

The integration of creativity still confronts teachers with the pedagogical dilemma of implementing it in the classroom. One option to integrate creativity is expanding STEM subjects (Science, Technology, Engineering, Mathematics) to interdisciplinary STEAM education (STEM with Arts). STEM subjects often do not enjoy a good reputation as they are regarded as stressful, sometimes even producing anxiety. The latter comprises feelings of tension and discomfort that might prevent a student from using their entire potential and could cause negative attitudes toward science [6]. This vicious circle, thus, causes negative attitudes towards individual abilities [7] creating barriers in STEM education by restricting problem-solving skills, e.g., [8]. Individuals need to perceive themselves as capable of coping with unknown situations and problems instead of becoming stressed and experiencing anxiety [9]. With their own experience, anxiety levels may decrease and self-efficacy may increase [10].

In search of a solution to this dilemma, STEM in combination with Arts is discussed to help to bridge these barriers [11]: STEAM could improve STEM's reputation, reintroducing creativity in the form of art. A better reputation could potentially regain students' trust by reducing stress and anxiety. STEM curricula, in their new format of STEAM education, may benefit from the integration of arts and creative aspects to encourage creative solutions [11]. Creativity, within the structural model of intelligence, is still defined as an unprecedented and effective way to solve problems [12]. According to this model, creative individuals need appropriate, appreciative environments.

Similarly, Holm-Hadulla [13] regarded creativity as a combination of talent, knowledge, ability, intrinsic motivation, and personality traits, and its expression influenced by environmental conditions. In consequence, creativity and intrinsic motivation are mutually dependent. Amabile and Tighe [14] described creativity as driven by intrinsic motivation. Links between motivation and dopamine-related activities were found at a neuronal level, functioning as a determinant of human creativity [15]. These cherish reasonable hopes that creativity might promote intrinsic motivation and emphasize the importance of creativity in (science) education.

Creative processes often involve a particular state of consciousness called "flow", characterized by complete absorption in an activity [16]. In this mental state, a person performing an activity becomes fully immersed in a feeling of energized focus, full involvement, and enjoyment. Flow is perceived as resulting in high intrinsic motivation scores. Unfortunately, the ability to experience flow vanishes with age and is probably replaced by knowledge-based, logical sense-making patterns [16]. A one-sided education based on listening and pure, testable knowledge transfer could encourage these tendencies.

1.2. Creativity Needed at School

STEM curricula nowadays are expected to benefit from the integration of arts or creative aspects, thus fostering creative solutions [11]. Subsequently, STEAM may help to develop critical thinking, also regarding real-world problems, and make science learning easier [11,17]. For the latter, a feasible definition of creativity would be the process of raising awareness to problems, closing gaps in knowledge, searching for solutions, and communicating results with peers [18]. It is a definition also fit for "Deeper Learning", which is understood as a "21st-century skill", with aspirations so ambitious that it would take more than a change of curriculums [19]. STEAM is, therefore, rather used to convey an attitude in which everyone scoops out their competencies (e.g., for problem-solving), which requires more than simple knowledge transfer.

Learning difficulties, especially in the case of negatively rated subjects, might be due to poor self-efficacy [20–22]. Self-efficacy, defined as judgment or assessment of one's capabilities to perform a particular given task successfully [9], is an element of intrinsic motivation [23]. It has been highlighted as an essential predictor of general academic performance [24]. Thereby, self-efficacy is regarded as a major trigger for purposeful behavior and the perseverance to achieve set goals, which usually results in good marks—or even leading to a science career [25]. These are soft skills that both teachers and training employers miss about the learners; they increasingly criticize what they see as the deficient career maturity of school graduates. Self-efficacy constitutes a leading non-cognitive construct related to problem-solving abilities [25] affecting behavior via feeling, thinking, acting, and self-motivating [9]. The latter is regarded as an inner drive that directs an individual's behavior toward the fulfillment of a goal. Both creativity and self-efficacy need a social environment of openness, where learners can experiment to explore their abilities and efficacies [12]. Self-efficacy may be the reason why there still are low numbers of women in scientific professions [26]. The missing women might not be a natural effect due to the talent and interests of boys or girls, but rather of a role-model-based conflict preventing girls from pursuing a science career [27]. To counteract this still prevailing trend, particularly girls could benefit from STEAM. First, the STEAM potentials described above could allow female students to experience their skills and competences in a STEAM lesson unbiasedly. Secondly, STEAM is regarded as establishing contact between students and professionals such as artists or scientists. Considering to serve both genders, in the face of female scientists, girls can rethink their role model [28].

Creative individuals report discovery processes as enjoyable experiences, bridging creativity and science as closely related fields [16]. Neglecting this bridge may lead to a focus primarily on learning rules in scientific environments without using its potential for creativity [16]. Learning environments following the theories of constructivism are more open, allowing learners to follow individual conceptions. This can serve as a guideline for other curricula to integrate creativity. Thus, creativity could be viable in educational settings that support the five steps of creative processes: preparation, incubation, eureka effect, evaluation, and elaboration [16]. Creativity can be inspired and fostered to preserve the ability for creative (flow) across all age groups [29].

1.3. Creativity-Promoting Features

Existing research in the field of creativity has mainly focused on individual, psychological, or personality variables, which, despite their importance, offer scarce practical advice to educators [4]. So far, only a few studies have focused on creativity-promoting practices in classrooms [30]. It is, however, critical to investigate how teachers can create environments that support creativity in educational settings. Many teachers may also believe that developing students' creativity is important, but lack the pedagogical strategies to do so [3]. Creativity-enhancing education is not a collection of interventions and techniques but a reconstruction of the learning environment whereby teachers constitute the most important motivational factor. Teachers need to reconsider their role within the classroom community, thus being less rigid, less structured, more hands-on, and more open to multiple options of learning [31]. From a psychological perspective, fluid thinking and association, as well as the ability to change perspectives, are essential. Readiness to open up to the unknown and preparedness to meaningfully process ideas are also to be considered. Several methods may foster creative thinking; for example, concept mapping, mind mapping, or variations of brainstorming [32,33]. Nonetheless, the social environment is more important for creative results than methods and techniques alone. Behaviors that promote or inhibit a creative potential are responsive to social backgrounds, working climates, and educational experience. Perfectionism may cause strict target orientation and problem-solving rituals to prevent mistakes, which could lead to fear, disappointment, failure, and mistakes [34]. A conducive error management culture, with no blame for failure, may help to avoid such problems. Other factors can be both supportive and obstructive for creativity: e.g., social distance impairs creativity [35]. Strong team spirit might promote self-censorship but could also prevent presenting new ideas to avoid separation from the group. Another cultural disadvantage might be rooted in the strict separation of work and play as playfully trying out different things could encourage the development of something new [16].

1.4. The Concrete STEAM Project: CREATIONS

A real synthesis of creativity and STEM is required to close identified needs and gaps. There is also a need for a critical review of how art should flow into the classroom. The administrative and methodological frame to integrate creative approaches in science education was a European-wide initiative with 16 partners to generate alternative ideas. Concretely, the common agenda focused on fostering everyday creativity, which was expected to result in purposive, imaginative, and activity-generating outcomes [36]. As there is hardly any space for creative work in science education at school, the commonly recorded low science interest of young people may originate in that lack.

The CREATIONS project was set up to overcome this development. In CREATIONS, a project funded by the European Union, 16 partners from ten European countries developed creative approaches based on art for an engaging science classroom. It breaks new ground to increase young people's interest in science, particularly by supporting the link between science and creativity. The partners provided a variety of events from one-day interventions to a one-year weekly projects with theater, photography, and exhibitions in which young people could experience an active and playful role within science and research. For instance, unique research infrastructures like CERN were supposed to act as catalysts for innovative science education to allow citizens of today and tomorrow to play a more active role in science. In compliance with the OECD Report on the impact of large-scale infrastructures [37], such scientific organizations could act as incubators for innovative ideas and projects (even outside the mainstream mission). The framework specifications of CREATIONS were supposed to embed this culture into science classroom settings. Furthermore, the cultivation of scientific spirit could help to overcome language and national curriculum diversities. Innovative methods of combining traditional science lessons with artistic pedagogical aspects may help educationally remote or multinational communities to experience cohesion and practice cooperative communication in order to achieve common goals.

CREATIONS is considered a potent mediator to contribute to engagement and change as, during the project, ideas were generated through individual, collaborative, and communal activities. The layer of communal engagement is particularly important regarding the societal level of Responsible Research and Innovation, and the idea that innovators need to be mutually responsive within and beyond their communities. The concept of communal engagement [38] acknowledges that creative working shapes the ideas and thinking of people who then only exist in groups with shared identities. Their body of thought can, however, be challenged by the inventiveness of other groups. This raises ethical questions that need to be considered [39] and the need to genuinely engage people in scientific debates and questions via education.

Of vital importance to nurturing empowerment and agency, dialogue, individual, collaborative, and communal activities for change and ethics and trusteeship are two more CREATIONS principles. The first is the importance of sound specialist knowledge. It comprises knowledge relevant to the respective science discipline but also cherishes the idea of different kinds of knowledge alongside those prioritized within the scientific realm. To initiate a dialogue that works mutually and does not remain a one-sided monologue, many scientists have to process their knowledge that they can convey their ideas to the "public". The second is the promotion of professional wisdom. At its heart, CREATIONS values the concept of teaching experts who contribute to professional wealth and intuitive teaching by sharing discipline knowledge and expertise; they cannot be viewed as mere 'information deliverers'. They can be a source of inspiration and become role models. It is their professional wisdom that makes the science learning process creative and engages children as well as young people in manifold ways.

There are hardly any internationally published studies measuring the impact of creativity and motivation [40]. The main goal of CREATIONS was to explore ways to spark young people's enthusiasm for science. Therefore, the effect on career motivation and self-reported creativity was examined for individual modules, e.g., [41–44]. The present study analyzed five selected best practices of CREATIONS across different fields of science (physics, math, and biology) focusing on creativity and motivation, with the latter focusing on self-efficacy as a factor of intrinsic motivation and specific career motivation.

Our research hypothesis was that learning environments following the CREATIONS guideline increase students' self-efficacy through experienced creativity, which results in increasing motivation. Therefore, we focused on the following three research questions: (i) Did the selected best practices affect the implemented scales measuring creativity and motivation? (ii) Is there a gender effect in science career motivation, self-efficacy or creativity? (iii) How are creativity and motivation related?

2. Methodology

2.1. Student Sample and STEAM Modules

Pre-post-schedule data of a sample of 928 students were analyzed (aged 9–18 years, M 12.57 ± 2.5; 506 females = 50.9 %). Bias was avoided, as participants were never aware of any testing cycles [45]. We selected five of the Creations modules for the analysis, which used the standard test design and had a sufficiently large number of participants. The selected five best practices implemented the Creations design [46], introducing creative elements based on the 5E Instructional Model proposing five phases: engagement, exploration, explanation, elaboration, and evaluation [47,48]. Creativity was integrated into the classroom environment as students were able to imagine, explore, experiment, test, manipulate, take risks, and speculate as well as to make mistakes [49]. For further detail, the interested reader may read the module descriptions on the Creations portal [50–54].

The modules were:

- 4D Math: aged 12–13, modeling in Mathematic in a regular classroom setting; informal hands-on mathematics and arts activity, three-lesson module with 4D-Math learning toolkits to design geometrical structures [50];
- Arts and Science across Italy: aged 14–18; several workshops within two years in which high school students prepare for a competition for which they are supposed to present scientific results in a work of art [51];
- Playing with Protons in Greece: 4th graders, aged 9–11, one-year weekly lesson in physics [52];
- Playing with Protons in the UK: 4th graders, aged 9–11, one-year weekly lesson in physics [53];
- Escape Malta: a one-day challenge workshop with puzzles about biology, mathematics, computer science, and programming of a robot [54].

To ensure the creativity-supporting social environment, teachers adopted the role of a tutor. They were responsible for a well-structured learning environment but left enough room for self-responsibility and development of self-efficacy for students to deal with problems and scientific questions. Creations paid attention to the well-identified "killers of creativity" [55].

2.2. Research Design and Tools

To measure influences of the Creations modules a before–after test design was applied. Students completed an online questionnaire before and after participation, which required about 25 min. As STEAM education is supposed to foster intrinsic motivation, we focused on self-efficacy and career motivation. We applied two subscales of the science motivation questionnaire [22]: career motivation (CM) and self-efficacy (SE), using a 5-point Likert scale pattern ranging from "never" (1) to "always" (5) (Table 1). To improve the applicability, we paid attention to the brevity of the questionnaires, and we have chosen the four best-loading items of each subscale. The strong factor structure of the entire toolset allows for this reduction in the item count, which has been confirmed in earlier studies [56,57].

Table 1. Items of the science motivation questionnaire: CM = career motivation, SE = self-efficacy.

Question	In order to better understand what you think and how you feel about your college science courses, please respond to each of the following statements from the perspective of: "When I am in a college science course . . . "
CM 1	Understanding science will benefit me in my career.
CM 2	Knowing science will give me a career advantage.
CM 3	Learning science will help me get a good job.
CM 4	I will use science problem-solving skills in my career.
SE 1	I am confident I will do well on science tests.
SE 2	I believe I can earn a grade of 'A' in science.
SE 3	I believe I can master science knowledge and skills.
SE 4	I am sure I can understand science.

For creativity measurement, we focused on the level of motivation and attitudes associated with personal creativity, as well as on the cognitive (thinking) and non-cognitive (motivation) dimensions of creativity [1]. We applied two subscales following the CPAC (cognitive processes associated with creativity) of Miller and Dumford [58] modified by Conradty and Bogner [59] (Table 2): Act quantifies cognitive processes of conscious and active thinking that can be trained and taught. Flow monitors typical elements of a flow experience [16], which supposedly assesses motivational experiences at school related to creativity. The creativity measure employed a 4-point Likert scale ranging from "never" (1) to "very often" (4).

Table 2. Creativity test CPAC: A = Act, F = Flow.

Question	During the current school year, about how often have you done each of the following?
A1	Tried to generate as many ideas as possible when approaching a task
A2	Asked other people to help generate potential solutions to a problem
A3	Looked at a problem or task from a different angle to find a solution
A4	Joined together dissimilar concepts to create a novel idea
A5	Incorporated a previously used solution in a new way
A6	Made a connection between a current problem or task and a related situation
A7	Imagined a potential solution to explore its usefulness
F1	Been fully immersed in your work on a problem or task
F2	Lost track of time when intensely working
F3	Felt that work was automatic and effortless during an enjoyable task

2.3. Data Analysis Procedure

For statistical analyses, IBM SPSS Statistics 26.0 and AMOS 26.0 were used. Outliers were rejected. Following the central limit theorem, we assumed normal distribution of the data [60] (p. 9). To answer question (i) about the effects of the modules, changes before and after the implementations were analyzed using a *t*-test. Regarding question (ii), Welch tests were used to measure gender differences [61]. To evaluate the relation of creativity and motivation (question iii) bivariate correlations and structural equation model (SEM) analysis were applied. The bivariate correlations and Spearman's Rho between the variables were analyzed to exclude the non-significant variables from the path analysis. Due to the large sample size, most parameters were highly significant, even if Bonferroni correction was applied. Thus, we analyzed a 10% random sample (Table 1). The SEM was based on theoretically valid variables and their bivariate correlations. Estimation discrepancy applied maximum likelihood. For the sake of completeness, we also considered age given the broad sample. Gender and Age had no effects; thus, Gender and Age were not included in the model. Act, Flow, and SE were used as covariates to control effects on measured Career Motivation (CM). The goodness of fit of the models was based on a chi-square test. While technically, chi-square should be non-significant in model testing ($p > 0.05$), this is very hard to achieve due to the usually large sample required for it. So if it is, in fact, significant on a low level ($p > 0.01$), this is irrelevant as other indicators of fit are good [62]. We assume indices of NFI (Normed Fit Index), TLI (Tucker-Lewis Index), and CFI (Comparative Fit Index) (good fit > 0.90, or better > 0.95), and RMSEA (Root Mean Square Error of Approximation) reasonable fit < 0.08, good fit < 0.05 [63]. Standardized beta coefficients and R^2 values reflect the total portion of variance explained by the predictor variables.

3. Results

All motivational parameters showed slight ceiling effects so that the highly significant increase in Self-Efficacy is even more striking (t (994) = 4.43, $p < 0.001$, Figure 1). The creativity factor Act increased (t (994) = 2.43, $p = 0.015$, Figure 1), Flow did not. In view of the broad sample for the sake of completeness, age effects were also calculated. No age effect or gender impact appeared (t-test no sig).

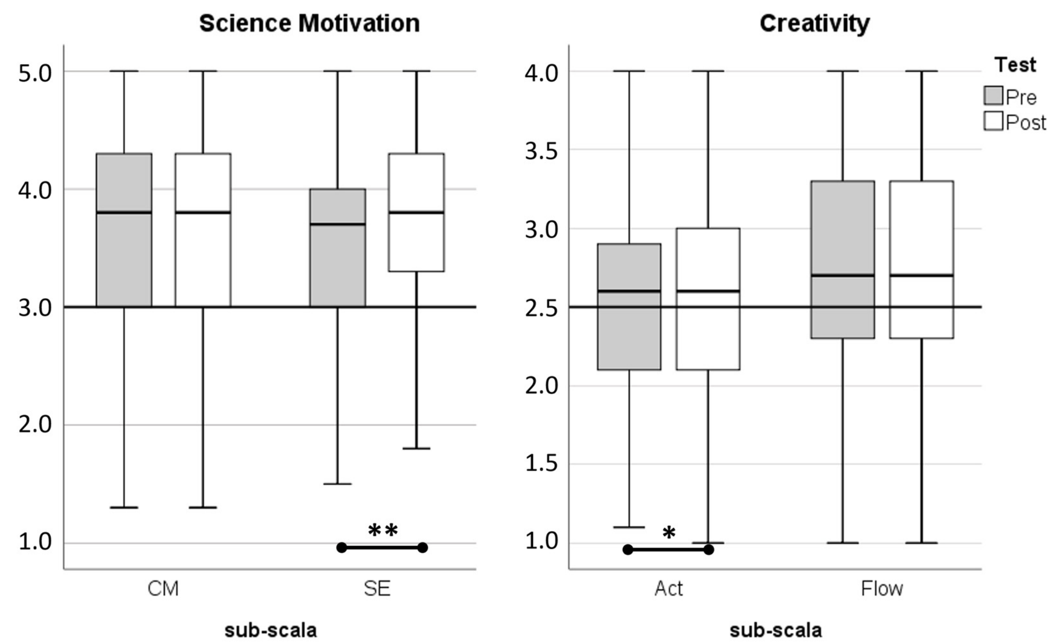

Figure 1. Boxplots of science motivation subscales "Career Motivation" (CM) and "Self-Efficacy" (SE) and creativity subscales "Act" and "Flow" at T0 and T1; * $p < 0.015$; ** $p < 0.001$.

The bivariate correlations between the variables were analyzed to exclude non-significant variables from path-analysis (Table 3). Gender was non-significant with any other variable and did not contribute to the model. Age correlated with Flow in the post-test, but not in the total sample. Both creativity parameters correlated with Career Motivation at any testing time, but with Self-Efficacy only in the post-test. The creativity parameters correlated strongly.

According to the correlation, CM was set as a controlled parameter, and SE, Act, and Flow as covariates to control the effect. The final model, containing only significant effects, fit the data well. The chi-squared statistic was insignificant ($\chi^2 = 5.676$, df = 1, $p = 0.017$) and the values of the relevant statistics of the goodness of fit were acceptable (NFI = 0.995; TLI = 0.958; CFI = 0.996; RMSEA = 0.069). The final path model is presented in Figure 2. The magnitude of the paths (the standardized beta-coefficients) are displayed with their levels of significance (*** $p < 0.001$) and the total variance explained by R^2.

Table 3. Bivariate correlations Spearman's Rho, 10% random sample N = 92.

					PRE TEST				POST TEST			
			Gender	**Age**	**CM**	**SE**	**Act**	**Flow**	**CM**	**SE**	**Act**	**Flow**
	Gender	**Correl.Coef.**		0.063	0.041	0.044	−0.008	−0.072	−0.042	0.061	0.02	0.087
		sig. 2-tailed		0.549	0.696	0.679	0.941	0.493	0.693	0.561	0.852	0.41
	Age	**Correl.Coef.**			0.033	−0.121	0.034	−0.237 *	−0.111	−0.251 *	−0.108	−0.283 **
		sig. 2-tailed			0.757	0.252	0.748	0.023	0.292	0.016	0.307	0.006
PRE TEST	**CM**	**Correl.Coef.**				0.371 **	0.379 **	0.325 **	0.461 **	0.119	0.11	−0.055
		sig. 2-tailed				<0.001	<0.001	0.002	<0.001	0.26	0.296	0.601
	SE	**Correl.Coef.**					0.461 **	0.261*	0.263 *	0.489 **	0.172	0.209 *
		sig. 2-tailed					<0.001	0.012	0.011	<0.001	0.101	0.046
	Act	**Correl.Coef.**						0.354 **	0.18	0.207 *	0.338 **	0.18
		sig. 2-tailed						0.001	0.085	0.048	0.001	0.085
	Flow	**Correl.Coef.**							0.183	0.326 **	0.193	0.295 **
		sig. 2-tailed							0.081	0.002	0.066	0.004
POST TEST	**CM**	**Correl.Coef.**								0.467 **	0.402 **	0.297 **
		sig. 2-tailed								<0.001	<0.001	0.004
	SE	**Correl.Coef.**									0.373 **	0.462 **
		sig. 2-tailed									<0.001	<0.001
	Act	**Correl.Coef.**										0.519 **
		sig. 2-tailed										<0.001
	Flow	**Correl.Coef.**										
		sig. 2-tailed										

Bonferroni Correction sig < 0.005; marks: ** ≤ 0.001, * ≤ 0.004.

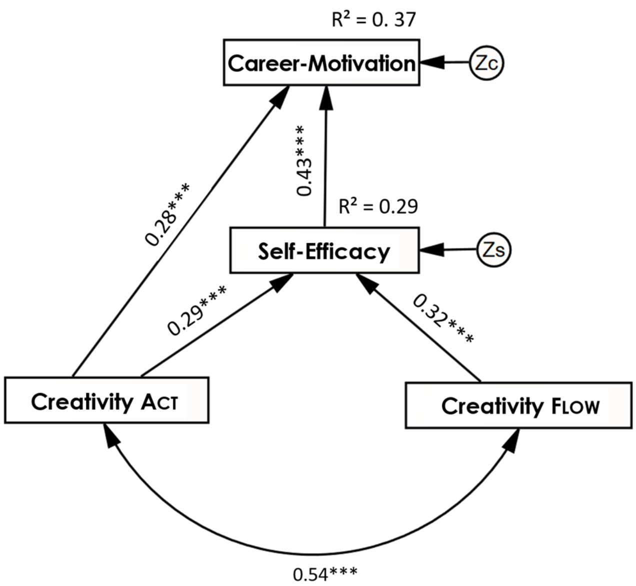

Figure 2. The structural equation model of Career Motivation through Creativity. *** $p < 0.001$.

4. Discussion

Integrating creativity into STEM matters. This key message of the present complex study is in line with previous studies focusing on sections of learning [17,41,43,44,64]. The analysis of several randomly selected modules of the Creations project illustrates a more general impact of STEAM education. Experienced personal creativity primarily promotes self-efficacy. The focus of this particular study was to motivate students with STEAM to pursue a science career. The results support the hypothesis that career motivation depends on individual self-efficacy, which in turn is strengthened by the perceived creativity. The finding of the SEM is in line with the current literature on career motivation, self-efficacy, and STEM lessons. The mutual interaction was modeled for the first time.

We hypothesized that STEAM (following the Creations guideline) increase students' self-efficacy through experienced creativity, which results in increasing motivation. To verify our hypothesis, we applied a three-step analysis: First, changes in motivation and creativity scores were calculated (Section 4.1.), and then tested for gender differences (Section 4.2.). In the third step, the hypothesized path model was checked using Spearman's Rho correlation analysis and SEM (Section 4.3.).

4.1. Changes in Career Motivation, Self-Efficacy and Creativity Factors Act and Flow

While both self-efficacy and cognitive creativity (Act) were affected, two other factors seem to be uninfluenced by our interventions: Career Motivation and Flow. Flow did not increase in many of the modules [17] and not in the overall average. This might be due to the wording of the questionnaire. On the other hand, flow describes a healthy mental state and can be regarded as stable. People experience happiness when they are fully engaged in a task that appears meaningful. This seems to be particularly easy for children, but as they age, the ability to be wholly immersed decreases. Adults know flow experiences from leisure activities rather than from work. Flow is experienced while painting, singing, dancing, or doing sports, e.g., [16]. Thus, even adults have the ability to experience flow, but unfortunately, flow often is not linked with business settings. One possible reason might be that flow needs a social environment where security and openness prevail [16]. To ensure a healthy society, this should not be ignored, as the ability to experience flow at work fosters satisfaction and success [12].

Act has shown an increase across all modules [17]. This subscale is linked to cognitive processes associated with creativity [58]. These active, cognitive creativity processes are fostered in a stimulating learning environment, where students are encouraged by mutual support to talk about experiences regarding similar problems, or to imagine a solution. An open classroom culture could, thus, enhance this cognitive form of creativity. Idea manipulation, imagery, incubation, idea generation techniques, analogical thinking, and imagination can actively be trained. All we need is to embed this way of thinking while providing an environment that allows for trial and error.

Self-efficacy is both task- and situation-specific [65]. Individuals make use of self-efficacy beliefs regarding specific goals [65]. Self-efficacy beliefs are sensitive to differences in contextual factors (e.g., changing environmental conditions) and personal factors (e.g., motivational level). Therefore, the recorded changes indicate that our module design created a motivating and strengthening working environment. Concerning science, STEAM modules have increased students' self-efficacy.

However, **Career Motivation** did not receive high scores across all of the five projects. On the one hand, this might be due to the youth of the students. They have not yet dealt with future careers due to their young age. On the other hand, students of this age group primarily focus on success at school. For this, the modules also strengthened their self-efficacy. For more mature students career motivation might be important, and the science motivation subscale Career Motivation may be meaningful. Younger adolescents may have not yet even thought about their future careers; thus, the subscale could not be measured. Nevertheless, due to its higher specificity, self-efficacy beliefs are often strong predictors of achievement outcomes if compared to other competence-related perceptions [66].

4.2. Gender Effects

Recent evidence from a neurophysiological point of view has demonstrated gender differences, for instance, regarding rewarding [67] or creativity [68]. Besides, women seem to be mostly absent from science careers [26]. Thus, we expected differences in motivation and creativity. While there is sufficient evidence to suggest gender differences, the gender effect often may not reach statistical significance levels, for instance, if the motivation is concerned [56,69–71]. This could be effected by self-reporting with a corrective shift of values. While girls exercise modesty in their self-assessment, it does not apply to boys [31]. However, the objectively observable data show that girls achieve better learning outcomes in STEAM [17,42], whereas boys are the ones who later pursue a science career [26]. Thus, the still low number of women in scientific professions might not be a natural effect due to the talent and interest of boys or girls but a role-model-based conflict preventing girls from pursuing a science career [27]. Establishing contact between students and female scientist could be beneficial to counteract this still prevailing trend [27,28], which was also considered throughout the implementation planning of Creations projects.

During creative tasks, [68] reported gender differences in communication between brain areas: in comparison to female brains, the male network organization is more local, more segregated, and more similar to small-world networks. These findings are in line with differences in divergent and convergent thinking and might indicate a neuronal difference in this gender-specific ability [72]. As sociodemographic factors impact gender differences in creative thinking [73], we recognize the importance to support both genders appropriately. Especially in STEM professions, women are still underrepresented, and the underlying reasons are much discussed but hardly researched, e.g., [26]. Csikszentmihalyi postulated that not gender itself, but a traditional gender differentiation in both boys and girls determines how they develop [16]. This cultural discrimination, which is also present in education, might explain the varying results of international studies about gender differences in creativity [16]. Nevertheless, gender differences in creativity studies still seem ambiguous. Besançon and Lubart [74] reported various studies supporting the hypothesis that women are considered more creative, while others claim the same for men or even deny that there are any differences [74]. The contradictory findings could be due to different research questions and varying levels of measured creativity. Physiological differences are probably overrated and do not matter for overall performance.

4.3. Structural Equation Model

Path analysis points to interrelations between creativity, self-efficacy and motivation. Self-efficacy and creativity, which are rooted in the same realm, promote each other and are in line with [75]. Self-efficacy and motivation are regarded as nested constructs [76]. The first one is regarded as a motivational measure connected to internal and external motivational factors. Motivation could be increased with reinforced self-efficacy expectations [9,24]. STEAM may transfer enthusiasm and individual self-efficacy from art to STEM, closing a "creativity gap" [75]. Educators could promote both creativity and intrinsic motivation by teaching students to solve problems that have no well-defined solutions.

Considering the great diversity in our sample with different projects, extensive age-span, different school types and strong simplification of the model, the model's quality characteristics are not as precise as might be required. Nevertheless, our analysis indicates a potential path with creativity fostering (career) motivation through self-efficacy. Act and Flow correlate strongly. Act, as an active cognitive process, satisfactorily increased after interventions, which, however, does not apply to Flow. With appropriate training of Act skills and enough time, it might be possible to increase Flow. Act also has a direct effect on career motivation and underlines the importance of students' activity for motivation. Creativity is considered an indicator of intrinsic motivation, and by increasing one, the other will adjust. Amabile and Fisher [55] regard as most creative people who are motivated primarily by interest, enjoyment, satisfaction, and the challenge of the work itself and not by external pressure. According to the "Intrinsic Motivation Principle of Creativity" [77] the social environment, particularly the presence or absence of external forces, influences creativity as it impacts people's passion for their work [55]. Leading creativity killers in both school and business are management schemes that limit perceived freedom [78].

5. Limitation

A limitation of the present study was the focus on career motivation, a subscale of science motivation. Because of their youth, participants apparently had not yet developed career maturity and concerning motivation. In this case, the science motivation subscale "career motivation" would have been too specific to measure increases in students' motivation. The intrinsic motivation subscale might show the effects of perceived creativity through self-efficacy to motivation, which needs to be proven by further studies.

The diversity of the five analyzed modules could be seen as another limitation of the study: The modules were in different STEM subjects for different age groups and of varying lengths. However, the Creations Guideline is common to all. Since all five modules, taken together, confirm the path model, this could even be seen as the strength of the study: no laboratory-like standardized conditions are required to verify the model, which indicates its generality.

6. Conclusions

Despite conflicting discussions of both creativity's definition and measurement, reintroducing creativity undoubtedly adds value to science classrooms. As science as such is driven by creativity and curiosity, science motivation and creativity naturally correlate. The relationship between creativity and interest provides promising teaching approaches [79] as interest is one of the most important motivational factors for learning. Thus, interest-based learning and the need to maintain and promote interest in education are undeniable. As creativity constitutes a combination of talent, knowledge, ability, intrinsic motivation, and personality traits that unfold in a supportive social environment [80], encouraging creative outcomes was always helpful. Many school systems, however, still may contribute to premature deterioration of creativity, in focusing primarily on knowledge acquisition [81]. This focus may have been a practical strategy, but it does not fit the complex digital environment of modern times. Scientific knowledge is rapidly changing; at the same time, access to updated knowledge is almost ubiquitous, which is why a focus on cognitive knowledge does not meet contemporary requirements. Interdisciplinary teamwork and complex, connected, and creative mindsets are required. STEAM may offer an educational roadmap for different teaching approaches and successfully prove that creativity promotes motivation through self-efficacy. This is an encouraging start for STEAM as a regular implementation.

An analysis of various Creation Modules has confirmed our hypothesis: career motivation—as a factor of maturity for vocational training [10]—depends on students' perceived self-efficacy. Frontal teaching, lectures, and school assignments do not enable an experience of self-efficacy. Completing school assignments with more or less success is rarely perceived as a personal cause, but rather as a fate that "happens" to them [82]. Self-efficacy must be experienced directly in the cause–effect principle. Basically, this happens with all forms of work, methods, interventions, and attitudes that enable creativity in the workplace. The Creations Guideline [46] gives a practical guideline on how teachers can strengthen motivation through self-efficacy: by developing STEM into STEAM with the focus on students' creativity.

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